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GALE & POLDEN'S MILITARY SERIES.

MILITARY SKETCHING

AND

MAP READING

FOR

NON-COMS. & MEN.

BY

MAJOR R. F. LEGGE,

The Leinster Regiment.

FULLY ILLUSTRATED.

THIRD EDITION

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MAJOR R. F. LEGGE

THE LEINSTER REGIMENT

Author of "Mainly About Shooting," "The Auxiliary Officers Handbook," "Guide to Promotion for Officers in Subject (a) (i)," "Magnetic Compass Sheet," "Scouts Alphabet," etc., etc.

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THIRD EDITION.

LONDON: GALE & POLDEN, LTD.,
2, AMEN CORNER, PATERNOSTER ROW, E.C.,
WELLINGTON WORKS, ALDERSHOT,
AND
NELSON HOUSE, PORTSMOUTH.

OR OF ALL BOOKSELLERS.

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ALDERSHOT:
PRINTED BY GALE & POLDEN, LTD., WELLINGTON WORKS.

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P. 2,316.

PREFACE TO FIRST EDITION.

Military Sketching and Map Reading are now, wisely, prominent features in the training of non-commissioned officers and men of both the Regular and Auxiliary Forces. That they have also become subjects of instruction in our Army Schools is further proof that the authorities recognize the immense utility of having, on active service, non-commissioned officers and men who can read a map accurately and can be trusted to turn out a sketch which will give an officer a fair idea of the ground it is intended to represent.

This little work has been written with the idea of assisting non-commissioned officers and men to gain a better grasp of the details of these subjects, which company officers may not have time to dwell upon in the individual instruction of those under them. It is hoped that, if studied in conjunction with the lectures given by Company Officers or Army Schoolmasters, it may help to elucidate many points on which men, seeking for further information, may feel reluctant to importune their Instructors.

My leading idea in compiling the little book, was to put in everything that a non-commissioned officer could possibly be expected to know about military sketching or map reading, and to arrange it all so simply, that a man with no previous knowledge of either subject could readily understand those things dealt with. Originality, save so far as methods of explanation are concerned, is obviously out of the question.

To be simple, clear and *brief*, would be to attain the ideal of a primer; if in some cases my explanations may seem to enter into a fair amount of detail in my anxiety to avoid any possibility of being misunderstood, the desire to come well within the capacity of men, who may be somewhat slow in grasping these matters, must be my apology.

R. F. LEGGE, *Major*,
Leinster Regt.

October, 1906.

PREFACE TO SECOND AND THIRD EDITIONS.

It is satisfactory to me to find another edition of this work called for already. I have noticed that great strides have been made in the subjects this book deals with, by Non-commissioned Officers of the Regular, Territorial Forces and Special Reserve, and to meet the demand I have had to include in this edition several points which were considered too advanced for Non-commissioned Officers some years back.

I trust that readers will find the explanations of the new matter dealt with as simple as heretofore.

R. F. LEGGE, *Major*,
Leinster Regt.

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MILITARY SKETCHING
AND
MAP READING
FOR
NON-COMS. & MEN.

CHAPTER I.

A MILITARY OR FIELD SKETCH.

A Military Sketch, or Field Sketch, is a map of a piece of country, such as may be made by an officer, non-commissioned officer or private soldier, with a view to give a Commanding Officer such information as he would be likely to require in the handling of troops, and for other military purposes. These sketches should contain nothing except what is absolutely necessary for military work.

No false information, nothing but what has been seen should be represented, and the tendency to sacrifice truth to effect must be guarded against.

There are several reasons why ordinary maps of the country are not sufficient ; one is because the contours are not generally shown, and even if they are shown, as is the case with ordnance maps, the vertical interval, or rise from one contour to another, is so great as to render the map not of much real value for tactical purposes, when dealing with a small piece of country such as that on which a battalion would have to manœuvre. The contours in ordnance maps are generally 100 feet, or at the least 50 feet apart. One can easily

imagine that during a 50 feet rise, there might be folds of ground, small hills, etc., behind which a brigade might be concealed with ease. Besides, new roads may have been made since the map was finished ; also, in all ordinary maps, details are invariably omitted, which are most essential for military work ; to quote an instance, it is very useful from a manœuvring point of view to know whether land is cultivated or not, whether crops are sufficiently high to give cover ; if fences or hedges have ditches alongside them that might be utilized as fire-trenches, etc. The difference between a "Military or Field Sketch" and a "Military Map or Survey" is, that the former is generally made by using a Prismatic Compass, Plane Table, or by Eye Sketching, therefore very great accuracy is not so much aimed at, as to give as true a representation of the country as possible, in the shortest available time ; on the other hand, a military map or survey is carried out by officers specially qualified, and with the use of such instruments as the Theodolite and the Sextant ; in this case, time is not so much an object as accuracy.

But though maps are made by experts, in contradistinction to sketches, all officers and non-commissioned officers must be able to "read" them readily. This requires study and attention and forms an important part of military education.

An important point to remember in executing a military sketch, either of an outpost position, a defensive position, or of an enemy's position, is to *enter on the sketch, the ranges to various distant conspicuous points that may not come into the actual area to be sketched.* Such ranges may be of the utmost value to an officer later on, and if no instrument is available to get an accurate estimate and the sketcher is unable to pace to these objects, their ranges must be judged a note to this effect being entered on the sketch.

CHAPTER II.

SCALES.

Every military sketch should have its scale and representative fraction attached to it.

It is necessary that scales should be thoroughly understood, as a complete knowledge of them is essential for those who have to read maps.

By the scale of a map or sketch is meant the proportion a certain distance on the map or sketch bears to the ground which it represents; or in other words, it denotes the proportion which a distance between any two points on a sketch or map, bears to the horizontal distance between the same two points on the ground.

The scale of a map depends on the amount of detail which you are required to show; for instance, in preparing the plan of houses, fortifications, etc., the scale will be a large one; whereas in military sketches of routes, roads, positions, or portions of country, the scale will be small.

Scales are expressed in three ways:

(*a*) By a statement in words, such as "6 inches to the mile" or "3 miles to the inch."

(*b*) By a line divided into parts, each part representing a certain number of units.

(*c*) By a representative fraction.

In a military sketch all these three should be shown.

A representative fraction (R.F.) is a fraction of which the numerator bears the same proportion to the denominator, that the map, or any distance on it, bears to the ground that it represents. The numerator is always 1 unit, and the denominator is expressed in similar units. The unit may be an inch, a foot, a yard, a metre, or any measure

ment. Thus, if the R.F. of a map is $\frac{1}{63,360}$, it means that one unit on the map represents 63,360 units on the ground. Thus the numerator of the R.F. must always be 1, and this 1 is always taken to mean one inch in English measure, therefore the denominator must, of course, be invariably expressed in inches, and must be that number of inches on the ground, which are represented by 1 inch on the map. So if the R.F. of a map is $\frac{1}{63,360}$, it means that 1 inch on the map represents 63,360 inches (or 1 mile) on the ground.

EXAMPLES.

(1) The scale of a map is 3 inches to a mile, give its R.F. :—

$$\text{R.F.} = \frac{\text{map}}{\text{ground}} = \frac{3''}{1 \text{ mile}} = \frac{3}{1 \times 1760 \times 3 \times 12} \quad \text{(or 1 mile brought to inches).}$$

$$= \frac{1''}{21120''} \quad (Ans.)$$

(2) The scale of a map is 1 inch to a mile, give its R.F. :—

$$\text{R.F.} = \frac{\text{map}}{\text{ground}} = \frac{1''}{1 \text{ mile}} = \frac{1}{1 \times 1760 \times 3 \times 12}$$

$$= \frac{1''}{63360''} \quad (Ans.)$$

The use of putting both the R.F. and the scale on a sketch is that the former will show, with a little calculation, at how many inches to a mile, or miles to the inch, the scale is drawn, and the latter is for the convenience of anyone using the sketch, to be able to measure distances at once. It is also evident that the larger the denominator, the smaller the scale.

For instance, if on looking at a map I see that the R.F. $= \frac{1}{10560}$, I know at once that 10560 inches on the ground

are represented by 1 inch on the map. Now to see what 10560 inches will be when reduced to miles :—

$$10560 \text{ inches} = \frac{10560}{36 \times 1760} \text{miles}$$

(because there are 36 inches in a yard and 1760 yards in a mile).

This works out as follows :—

$$\frac{\begin{matrix}1\\ \not{3}\\ \not{3}\not{3}\\ \not{1}\not{3}\not{2}\\ \not{1}\not{0}\not{5}\not{6}\not{0}\end{matrix}}{\begin{matrix}\not{3}\not{6} \times \not{1}\not{7}\not{6}\not{0}\\ \not{9}\quad \not{2}\not{2}\\ 3\quad 2\end{matrix}} = \frac{1}{6}$$

$\therefore$ $\frac{1}{6}$th of a mile is represented by 1 inch on the map.

$\therefore$ 1 mile is represented by 6 inches, or the scale is 6 inches to 1 mile.

Again, we find that the R.F. on a foreign map, the scale of which may show French metres or Russian versts, at once conveys to our mind what the scale of the map is in English units of measure, when we work out the R.F. as above.

The fact also that $\frac{1}{63,360}$ is the representative fraction of a scale of 1 inch to 1 mile will give us the following points :—

Any representative fraction where the denominator is greater than 63,360, will denote that the scale is one of miles to the inch ; if less than 63,360 it will denote that the scale is one of inches to the mile. To find out the exact proportion of the scale—

(*a*) If the denominator is greater than 63,360, divide it by 63,360, and the result will give the proportion of the scale in miles to the inch.

(*b*) If the denominator is less than 63,360, divide 63,360 by this denominator, and the result will give the proportion of the scale in inches to the mile.

EXAMPLES.

(1) R.F. $= \frac{1}{100,000}$; denominator is greater, as in case (*a*).

$$
\begin{array}{r}
63{,}360)100{,}000(1{\cdot}57 \\
63{,}360 \\
\hline
366{,}400 \\
316{,}800 \\
\hline
496{,}000 \\
443{,}520 \\
\hline
52{,}480
\end{array}
$$

$\therefore$ scale is 1·57 miles to the inch.

(2) R.F. $= \frac{1}{10,000}$; denominator is less, as in case (*b*).

$$
\begin{array}{r}
10{,}000)63{,}360(6{\cdot}33 \\
60{,}000 \\
\hline
33{,}600 \\
30{,}000 \\
\hline
36{,}000 \\
30{,}000 \\
\hline
\end{array}
$$

$\therefore$ scale is 6·33 inches to the mile.

Now a scale on a military sketch is usually made between 4 and 6 inches long, there is no particular reason why it should be this length, except that it is a convenient length to put at the bottom of any small sketch. Therefore there is no reason to worry oneself to get any exact length; any length that *is over 4 inches and under 6 inches* will do perfectly well, and beginners should thoroughly realize this fact.

Scales are graduated so as to show convenient distances; for instance, a scale of yards might be divided to show hundreds of yards, and the first hundred might be sub-divided into 10 parts, each part showing 10 yards; this in most cases would be a sufficient graduation.

The size of the scale used in field sketches depends on the object with which the sketch is made, and the amount of information required. The following examples are quoted from the Field Service Pocket Book :—(*a*) Camps or billeting areas, defence of villages, etc., scale 4″ to a mile and upwards; (*b*) road or river sketch, outpost positions, etc., 1″ to 4″ to a mile; (*c*) general maps or sketch of districts, $\frac{1}{4}$″ to 1 mile.

TO CONSTRUCT A SCALE.

You have to think of *three* things.

(1). *What is the proportion at which I am to draw this scale?* This proportion must be given you either in the form of a statement in words such as "at 6 inches to the mile" or "at 3 furlongs to the foot," or else in the form of an R.F., as $\frac{1}{8000}$, or $\frac{1}{25000}$, etc.

(2). *What are the units which I am required to show?* This also is given you in the following way: "Construct a scale R.F. $= \frac{1}{500}$ *showing yards*;" or construct a scale of *yards* at 6 inches to the mile. "Yards" is the unit in both these cases, and you can show tens of yards, hundreds of yards, or even single yards, according to the nature of the scale, so long as you do not make the sub-divisions too small. On the other hand you may be told to "Construct a scale of miles," R.F. $= \frac{1}{100000}$, in which case "*miles*" is the unit, and you may show single miles or tens of miles as may be convenient. But as we are dealing with military sketching we can take it for granted that scales of yards will be all that we shall require, except if the sketcher should be inconvenienced by pacing yards and step only paces of 30″ or so, when a scale of paces would be required; this we will go into later.

(3). *What number of these units, discussed in* (*2*), *must I take in order to give me a line between 4 and 6 inches long,* at the required proportion mentioned in (*1*).

Now this is where the beginner finds a little difficulty; after some practice he will be able to work out this number roughly in his head, but at first a little rough working out, at the bottom of the paper, which is afterwards rubbed out, will be required.

The best way to explain the construction of scales is to work out a few examples in absolute detail, so that the beginner can follow each separate step.

EXAMPLE 1.—Construct a scale of yards, the R.F. of which is $\frac{1}{400}$.

We are required at a proportion of $\frac{1}{400}$ to construct a scale, where the units shown will be yards.

Therefore, we must ask ourselves this question, "*What number of yards at a proportion of "R.F.* $= \frac{1}{400}$," *will give us a line between 4 and 6 inches long?*"

As we have not yet arrived at the stage where we can say at a glance 60 yards will be about a right number, we will proceed to work it out.

We know from the R.F. that 400 inches on the ground are represented by 1 inch on the map.

$\therefore \frac{400}{36}$ yards on ground are represented by 1 inch on map; in other words between 10 and 11 yards on ground are represented by 1 inch on map. Therefore, about five times this number will give a line about five inches long.

Now we must select a round number, so that we can graduate (or divide up) our scale easily into small divisions.

If we were to select 55 we would not be able to divide our line into 10's, or divisions easy to read. Therefore, we take 60 yards being a *round number.*

Now, having decided on our number of units, we must find out the *exact* length of line which will represent 60 yards at the proportion R.F. $= \frac{1}{400}$. Again we must work out a proportion sum.

We know 400 inches on ground are represented by 1 inch on map.

$\therefore \frac{400}{36}$ yards are represented by 1 inch on map.

$\therefore$ 1 yard is represented by $\frac{36}{400}$ inches on map.

$\therefore$ 60 yards are represented by $\frac{\cancel{36}^{9} \times \cancel{60}^{3}}{\cancel{400}_{10}}$ inches.

$$= \frac{27}{5} \text{ inches.}$$

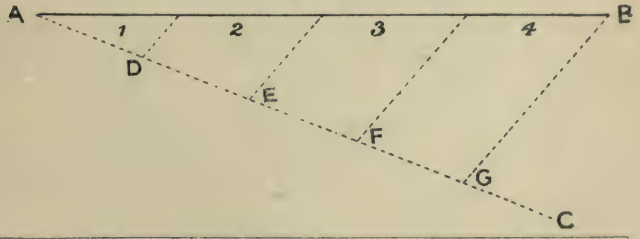
$$= 5{\cdot}4 \text{ inches (length of scale).}$$

The next thing to do is to measure a line 5·4 inches* long, and divide it into six equal parts; each of these parts will represent 10 yards. Subdivide the 1st division into two parts, each will represent 5 yards.

To divide a line into any number of equal parts, the best way is to draw an auxiliary line from one end of it, at an angle of about 30°, and measure off on this line with the dividers or protractor, the same number of equal divisions (only of any convenient length) you wish the original line to be divided into; join the point of the last division with the extremity of the line to be divided, and draw other lines parallel to it from each of the points that were measured off.

Example.—Divide a line AB which is 3″ long into 4 equal parts :—

AC is the auxiliary line; D, E, F and G are the 4 equal divisions set off along AC.

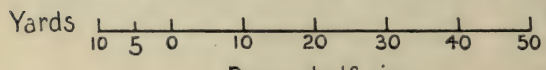


*The method of measuring decimal points (such as ·4, etc., of an inch) is explained in Chapter V. on the Protractor.

To return to the scale, a line 5·4″ is measured off the protractor, and divided by the above method into 6 equal parts, and the first division subdivided into 2 parts, showing distances of 5 yards.

The scale is then numbered off as below, the lines which were drawn to divide it up being rubbed out. The 1st division is always numbered 0, and then sub-divided as required. This is done for convenience, as, supposing we wished to measure off 25 yards or 35 yards, we would measure from the figures 20 or 30 to the figure 5, respectively.

Scale R.F. $\frac{1}{400}$ or 11·1 Yards to the inch



Drawn half size

If a scale had to be constructed at so many inches to a mile, the proportion sum is at once proceeded with, and the scale finished off as before, as in the following example :—

Example 2.—Construct a scale of 3″ to a mile, to measure yards :—

Now here our unit is yards, so we must ask ourselves, *how many yards must we take at the proportion of 3 inches to 1 mile to give us a line between 4 and 6 inches long ?*

We have 1 mile on ground represented by 3 inches on map.

In other words, 1760 yards on ground are represented by 3 inches on map.

We shall want about half as many yards again to give us a line between 4 and 6 inches long, *i.e.*, 1760 + 880 = 2640 yards.

In *round* numbers let us say 3000 yards.

Now, to work out exact length of line,

1760 yards are represented by 3 inches.

$\therefore$ 1 yard is „ „ $\frac{3}{1760}$ „

$\therefore$ 3000 yards are „ „ $\frac{3 \times 3000 \text{ inches}}{1760}$

$$= \frac{3 \times \overset{150}{\cancel{3000}}}{\underset{88}{\cancel{1760}}} = \frac{450}{88}$$

$= 5.1$ inches (length of scale).

Construction.—Draw a line 5·1 inches long, divide it into 6 equal parts, each part will represent 500 yards, subdivide 1st division into 5 equal parts, each subdivision represents 100 yards, or by subdividing the 1st division into 10 equal parts, each sub-division represents 50 yards.

COMPARATIVE SCALES.

Comparative scales are those which have exactly the same R.F., but the graduation is different.

Suppose a scale of yards and paces was required R.F. $\frac{1}{500}$ (1 pace = 30 inches).

The scale of yards would be drawn as described in example 1.

The scale of paces would be constructed as follows :—

$$\text{R.F.} = \frac{1}{500}$$

500 inches on ground are represented by 1 inch on map.

$\therefore$ $\frac{500}{36}$ yards „ „ „ „ „

Roughly speaking nearly 14 yards to 1 inch. Now a pace is 30 inches, or $\frac{30}{36}$ of a yard (*i.e.* $\frac{5}{6}$ of a yard), therefore,

as a yard is equal to $1\frac{1}{5}$ paces, there will be $\frac{1}{5}$ more paces to the inch than yards.

We have from above that 14 yards (about) are represented by one inch.

$\therefore$ we shall have $14 + (\frac{1}{5}$ of $14)$ paces to one inch.

$= 16\frac{4}{5}$ paces to 1 inch.

$\therefore$ To get a line between 4 and 6 inches long we shall want to take *about* $16\frac{4}{5} \times 5$ paces $= 84$ paces.

In round numbers let us take 90 paces.

Now to ascertain exact length of line we have from above 500 inches (ground) are represented by 1 inch on map.

$\therefore \frac{500}{30}$ paces are represented by 1 inch.

$\therefore$ 1 pace is " " $\frac{30}{500}$ inches.

$\therefore$ 90 paces are " " $\frac{30 \times 90}{500}$

$= \frac{27}{5}$

$= 5{\cdot}4$ inches (length of scale)

Draw a line 6 inches long, divide it into 10 equal parts, each part will equal 10 paces, sub-divide 1st division into 9 equal parts, each subdivision will equal one pace.

TIME SCALES.

A very useful scale when out either sketching or finding the way about country with a map, is a *time scale.*

This is a scale where the units of measure shown are units of time, as for instance "minutes."

Suppose you are out scouting on horse-back, you know the average pace your horse trots or canters and you are using an ordnance map; if you construct a scale of minutes, you have only to time yourself riding from a certain point,

measure that number of minutes from your time scale and plot off that distance from your starting point on your map, to find out exactly where you are on the map. This is useful over open country where landmarks are few and you know the compass bearing of the direction in which you are moving.

Out sketching on horse-back you time yourself riding from point to point, measure from your scale and plot off the distance on your sketch.

We will now work out some examples of time scales, so as to make them more easily understood.

(1) Your horse (*a*) trots 5 miles per hour, and (*b*) canters 8 miles per hour. Construct scales for use in both cases to suit the map you are using, which is an ordnance, 6 inches to one mile.

(*a*) *Trotting Scale.*—5 miles an hour

$$\text{is the same as } \frac{5 \times 1760}{60} \text{ yards a minute.}$$

$$= \frac{440}{3} \text{ yards a minute.}$$

The scale of the map we are using is 6 inches to 1 mile.

This is the proportion of the scale.

Note also that the units of measure are to be minute and a minute $= \frac{440}{3}$ yards.

1 mile is represented by 6 inches, or in other words :—
1760 yards is represented by 6 inches.

$$\therefore 1 \text{ yard is represented by } \frac{6}{1760} \text{ inches.}$$

$$\therefore \frac{440}{3} \text{ yards (or 1 minute) is}$$

$$\text{represented by } \frac{6}{1760} \times \frac{440}{3} \text{ inches.}$$

Working this out we get

$\therefore$ 1 minute is represented by $\frac{1}{2}$ inch.

Our scale should be between 4 inches and 6 inches long.

$\therefore$ 10 minutes is represented by $10 \times \frac{1}{2}$

$= 5$ inches (length of scale).

To construct the scale:—Draw a line 5 inches long, divide into 10 equal parts; sub-divide the 1st part into 4, each of which is a quarter of a minute.

(*b*) *Cantering Scale.*—8 miles per hour

is the same as $\frac{8 \times 1760}{60}$ yards per minute

$= \frac{704}{3}$ " " "

Again the scale of map used is 6 inches to 1 mile.

From this we have—

1760 yards are represented by 6 inches,

$\therefore$ 1 yard is represented by $\frac{6}{1760}$ inches.

$\therefore \frac{704}{3}$ yds. (or 1 minute) is represented by $\frac{6}{1760} \times \frac{704}{3}$ ins.

Working this out we get

$\therefore$ 1 minute is represented by $\frac{4}{5}$ inches.

Scale to be between 4 and 6 inches long.

$\therefore$ 7 minutes is represented by $\frac{4}{5} \times \frac{7}{1}$ inches.

$= \frac{28}{5}$

$= 5{\cdot}6$ inches (length of scale).

To construct the scale, draw a line $5{\cdot}6$ inches long, divide into 7 equal parts, sub-divide first part into 4 divisions, each of which represents a quarter of a minute.

DIAGONAL SCALES.

Diagonal scales are for making minute measurements, and almost all that is required, as far as military sketching is concerned, will be found on Gunter's or Gale and Polden's protractor, on which there are diagonal scales.

OTHER HINTS ON SCALES.

It is recommended that sketches of roads, rivers, and positions, should be drawn to a scale of 1 to 4 inches to a mile.

Before leaving scales, we will take two more examples: (1), knowing the scale of a map is so many inches to a mile, to find the R.F.; (2), measuring the distance between two places you find them to be so much, and measuring their distance on the map, they are so many inches; what is the R.F.?

In the first case, suppose the scale of a map to be 5″ to a mile, what is the R.F.?

Make a fraction of it, placing the 5″ as numerator, and 1 mile denominator, reduce the mile to inches, then divide the numerator into the denominator, thus leaving the numerator unity.

EXAMPLE. $\frac{5 \text{ inches (map)}}{1 \text{ mile (ground)}} = \frac{5}{1 \times 1760 \times 3 \times 12}$

$= \frac{5}{63360} = \frac{1}{12672}$ R.F.

In the second case, the following example will explain:—

The distance between two trees is measured and found to be 500 yards; on a map they are shown 2 inches apart; to find the R.F. we proceed as before:—

$\frac{2 \text{ inches}}{500 \text{ yards}} = \frac{2}{500 \times 3 \times 12} = \frac{2}{18000} = \frac{1}{9000}$ R.F.

EXAMPLES OF SCALES.

Examples of scales to be worked out by students. Answers showing full working will be found in appendix at end of book.

(*a*) Construct a scale of yards at 4 inches to the mile.

(*b*) Construct a scale of yards R.F. $= \frac{1}{10000}$.

(*c*) Construct a scale R.F. $= \frac{1}{15000}$, showing furlongs.

(*d*) The distance between two places on a map is measured and found to be 3·6 inches; when paced on the ground it is found to be 890 yards; draw a scale of yards for this map.

(*e*) You are detailed to make a road reconnaissance at a scale of 1 inch = 1 mile. You have a bicycle which you intend to use while sketching; it travels 5 yards for one revolution of the pedal. Construct a suitable scale of revolutions.

(*f*) You are about to make a sketch on horseback on a scale of 2 miles to 1 inch, and you know that your horse trots at the rate of 7 miles per hour.

Draw a *scale of time* suitable to work with and give the representative fraction.

CHAPTER III.

DEFINITIONS.

Before proceeding further, the following definitions should be studied :—

Topographical Forms.

Basin.—(*a*) A small area of level ground surrounded, or nearly surrounded, by hills ; (*b*) a district drained by a river and its tributaries, as the "basin of the Thames."

Col.—A depression between two adjacent mountains or hills, or a break in a ridge ; or the neck of land which connects an outlying feature with a range of mountains or hills, or with a spur.

Crest.—The edge of the top of a hill or mountain, the position at which a gentle slope changes to an abrupt one ; the top of a bluff or cliff.

Hill.—High ground which falls away on every side. If over 3,000 feet in height it is called a mountain.

Knoll.—A low detached hill.

Nullah or Donga.—The dried up bed of a river or stream.

Plateau.—A flat surface on the top of a hill ; in other words an elevated plain.

Ravine.—A narrow valley with steep sides.

Re-entrant.—A "re-entrant" occurs where the hill-side is curved inwards towards the main feature ; it is always found between two salients.

Saddle.—A Col.

Salient or Spur.—A projection from the side of a hill or mountain, running out and down from the main feature.

Tableland.—A high-lying level district of country.

UNDERFEATURE.—A minor feature, an offspring of a main feature.

UNDULATING GROUND.—Ground consisting of alternate gentle elevations and depressions.

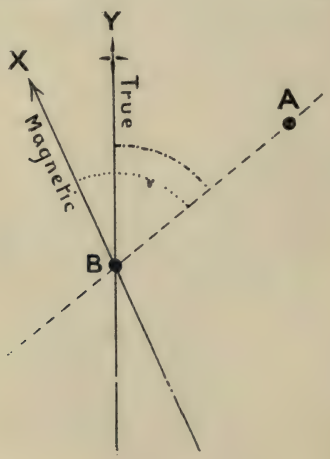
WATERCOURSE.—The line defining the lowest part of a valley, whether occupied by a stream or not.

WATERSHED.—A ridge of high land separating two drainage basins; the summit of land from which water divides and flows in two directions. A watershed does not necessarily include the highest points of a chain of mountains or range of hills.

TECHNICAL TERMS.

BASE OR BASE LINE.—Base is the starting point of a survey. It is a carefully chosen and accurately measured line, upon which the accuracy of a triangulation depends. It should vary for military sketches from 400 to 1,000 yards; a good view of the country should be obtainable from both ends.

BEARING.—True bearing is the angle a line makes with the true north line.



Magnetic bearing is the angle a line makes with the magnetic north line.

To explain more fully what is meant by the *bearing* of an object, a little more detail is essential.

The magnetic bearing of an object (A) *from* another object (B) is the angle which a line drawn from (B) to (A), makes with a line running through (B) in a magnetic N. and S. direction, *i.e.*, the angle XBA in figure.

This angle is the *magnetic bearing* of the object (A).

A true bearing would be the angle made by the line (B) (A), with a true N. and S. line running through (B), *i.e.*, the angle YBA in the figure. This angle YBA is the true bearing of the object (A).

Contour.—An imaginary line running along the surface of the ground at the same height above mean sea-level throughout its length; or, the outline of a plane surface which would be exposed when a hill is cut by a horizontal plane. Each contour represents a fixed rise or fall of so many feet from the ones next to it. This fixed rise or fall is termed the vertical interval (V.I.).

A Gradient is a method of expressing a slope by a fraction, the numerator of which is 1, representing 1 foot, the denominator being that number of feet you have to move horizontally before you have risen 1 foot.

Thus $\frac{1}{50}$ represents a rise or fall of 1 foot in a horizontal distance of 50 feet.

H.E., or horizontal equivalent, is the horizontal distance in which a given difference of level will occur at a given degree of slope; always stated in yards, *i.e.*, *it is the distance in yards between two contours on a map.*

Magnetic Meridian.—A magnetic north and south line.

Meridian.—A true north and south line.

A Ray is a term used when plane-tabling to express the *direction* of an object. When working a plane-table it is incorrect to speak of "bearings," we should say "rays" instead. A magnetic bearing is the direction *of an object with reference to the magnetic meridian through the point of*

observation, whereas a ray is the simple direction of an object, without any reference to the points of the compass, taken by means of aligning a ruler by eye on to the object from the point on your sketch representing your point of observation.

SECTION.—The outline of the intersection of the surface of the ground by a vertical plane.

A little explanation of a more detailed character might come in useful here.

The first thing to understand is what is meant by a *vertical plane.*

A *plane* or plane surface, is one which has length and breadth, but *no depth or thickness*—the nearest approach to it is a sheet of paper. A *vertical plane*, then, is one where this sheet of paper is held up at right angles to the ground or earth's surface—a horizontal plane is one where this sheet of paper (so to speak) is held parallel to the earth's surface. To further explain a section as defined above—say you have a cake and place it on a table, and then with a knife held so that its flat surface is at right angles to the earth's surface, you cut clean through the cake on to the table, remove one of the portions cut and you expose a *section*, the outline of which would be indicated by the brown crust of the cake.

TRIANGULATION OR INTERSECTION is the process of accurately fixing the position of important points on the area to be surveyed or sketched, by means of a measured base and a chain or network of triangles dependent on it, obtained by the intersection of bearings.

Triangulation is applied to a survey where accuracy is minutely considered. Intersection is applied to a military sketch where the work is only approximately accurate.

V.I.—The vertical interval between two adjacent contours or the height of one contour above another; always stated in feet.

CHAPTER IV.

THE MAGNETIC COMPASS.*

The magnetic compass is made up of three parts:—(*a*) The box, (*b*) the magnetized steel needle, (*c*) the card.

The box is shallow, circular, and made of metal; from the centre of the bottom of it there projects a small pin made of hardened steel; on this pin is balanced the needle. The box usually has a glass face like a watch.

Good compasses have a folding sight-vane and a prism attached to the box—the sight-vane has a horse-hair down the centre and the prism a V-shaped slot. A sight is taken through the V-shaped slot on to the object, and the horse-hair is then brought into the alignment (as in sighting a rifle).

The needle consists of two steel arms of equal length fitted on to a hollow circular cup; this cup fits over the pin. One end of the needle is magnetized by being rubbed with lodestone, a stone of peculiar attractive properties, the result being that when the needle is balanced by dropping the hollow cup on to the pin, and is allowed to revolve freely, it will come to rest with the magnetized end pointing *in the direction of* the true north. This particular end is coloured black or shaped in such a manner as to render it conspicuous; it does not point actually at the true north, but a little away from it, either to the east or west, this distance varying in different parts of the globe.

The direction in which the needle actually points is therefore termed the *Magnetic North*, whilst the amount which it points away from true north is termed the "*variation*" of the compass; this latter is measured in degrees and said to be east or west of true north according to whether the needle points east or west of the true north.

* The Magnetic Compass and How to Use It, fully illustrated with Diagrams. In sheet form, size 21ins. by 26ins., price 6d., and in book form, price 9d. Compiled by Major R. F. Legge, The Leinster Regt. To be obtained from Gale & Polden, Ltd.

The Compass Card is circular (see illustration on opposite page) and is either fixed to the bottom of the box with the needle revolving freely on the pin above it, or it is fastened on top of needle and revolves with the needle, the magnetized end of which is placed immediately beneath 0° or 360°.

The rim of the card is divided up according to two methods.

(*a*). Into 360 equal divisions, known as degrees (and shown thus "°"); the illustration is only numbered at every 10° to prevent crowding of figures.

(*b*). Known as the *Mariner's Compass*; the rim is divided into 32 parts, or "points of the compass"—the four principal points, *i.e.*, N., S., E., W., are termed the "*cardinal points*"—each point is therefore equal to $\frac{360}{32} = 11\frac{1}{4}$ degrees.

We see from the figure, that calling N. 0° or 360° (both the same thing) we get E. to be 90°, S. to be 180°, and W. to be 270°.

It will also be useful to commit to memory the points that lie immediately between the four principal cardinal points, *i.e.*:—

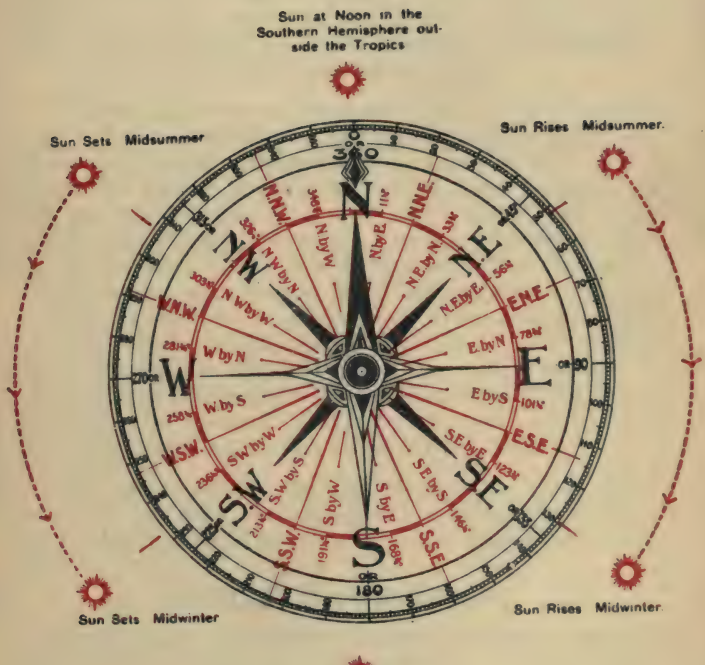
N.E. = 45°; S.E. = 135°; S.W. = 225°; and N.W. = 315°.

The reader should now be able to realize that the term "*magnetic bearing*" of an object (defined in previous chapter) indicates the general direction of any distant object, as seen from an observer's position, which is measured in degrees by means of the compass, in regard to the position it occupies with reference to the magnetic north.

The Position of the Sun at Various Times.

Before dealing with the variation of the compass, a few words will be necessary to explain the positions of the sun as shown in Plate I.

PLATE . I.


Sun at Noon in the Southern Hemisphere outside the Tropics
Sun Sets Midsummer
Sun Rises Midsummer.
Sun Sets Midwinter
Sun Rises Midwinter.
Sun at Noon in the Northern Hemisphere outside the Tropics
N
NNE.
NE
ENE.
E
ESE.
SE
SSE.
S
SSW.
SW
WSW.
W
WNW.
NW
NNW.
N by E.
N.E.by N.
N.E.by E.
E.by N
E by S
S.E.by E.
S.E.by S.
S by E
S by W
S.W.by S.
S.W.by W.
W by S
W by N
W.N.W.
N W by W
N W by N
N.N.W.
OR 180
OR 90
OR 270
OR 360

The sun rises in the east and sets in the west, *within the limits marked on the figure.*

That is, on Midsummer Day (June 21st) the bearing of the sun observed when it rises is about 51½° (see Plate I.). When it sets the bearing is about 309½°. On Midwinter Day (December 21st) the bearing is about 128½° when it rises and 231½° when it sets. It is only during the equinoctial seasons, when the length of the days and nights are about the same (*i.e.*, about March 21st and September 21st) that it rises due east and sets due west.

The next point to observe is the position of the sun at noon. Before going into this we must thoroughly understand about the tropics. There are two imaginary lines drawn around the surface of the globe parallel to the Equator, and one, the Tropic of Cancer, is a certain distance north of the Equator, whilst the other, the Tropic of Capricorn, is a certain distance south of the Equator. The distance is 23½° where a degree is equal to 60 nautical miles, but this does not concern us. In the regions between the two belts, known as the Torrid Zone, commonly called "the Tropics," the sun at noon is vertically above the earth's surface; in the regions of the Northern Hemisphere, north of the Tropic of Cancer, the bearing of the sun at noon is practically due south, *this being the case in the British Isles.*

In the regions of the Southern Hemisphere, south of the Tropic of Capricorn, the bearing of the sun at noon is practically due north. This is the case in places like South Africa.

VARIATION OF COMPASS.

By variation of the compass, as already explained, we mean the number of degrees that any particular compass needle may vary from true north, in other words, may point away from true north.

The variation of any compass may be found by taking the bearing of true north with it. If the bearing read is 360°, there is no variation; if it does not read 360° the variation then is the number of degrees between 360° and

whatever the bearing is, that has been read, and it is east or west of true north, according to which way the magnetic needle points.

For instance, we know that a certain road runs due north and south, either from the Ordnance map, the sides of which are always true north and south, or other reliable source of information. We take the bearing down the centre of this road, or from one lamp-post to another on same side, if such exist, and we find it to be 350°. What is the variation of the compass?

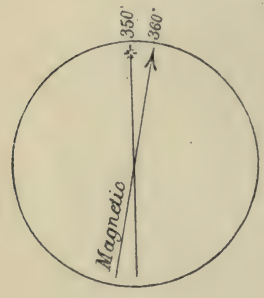


Fig. 1.

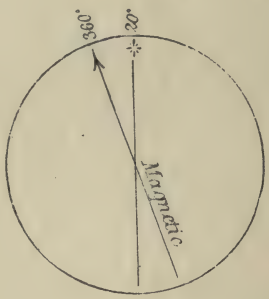


Fig. 2.

From Fig. 1 above, we see that if the bearing of true north (always marked with a star) is 350°, the magnetic needle which must be at 360°, comes on the right or east of true north and in this case the variation is therefore 10° E.

If the bearing of true north, however, turned out to be 20°, we see from Fig. 2 that the magnetic needle, which must be at 360°, would come left of true north, and in this case the variation of the compass would be 20° W.

The variation of the Compass in England. This varies at the present time between 15° W. in the east of England and 18° W. in the west and north. It will suffice, however, if we call the magnetic variation 15° W. If we wish to ascertain the actual direction of the true north from the compass we must first

hold the compass on a flat surface (or in palm of hand), allow needle and card to steady, when a line running from the centre of the compass (the cup) through the figures (15°) on the rim will give the direction of the true north. If the compass has a fixed card, allow needle to steady, then twist box round quietly without disturbing direction of needle until 0° or 360° comes under magnetized end of needle, then a line, as above, through centre of compass and 15° on rim gives direction of true north.

N.B.—It is well to remember in measuring with a protractor *the magnetic bearing* of one object (A) from an observer's position, (B) from off the ordnance map (the sides of which are true north and south), we must add 15° on to the angle formed between the line drawn between the two points (A and B) and the true "north and south" line (*i.e.*, a line parallel to sides of map) running through B.

Again, if we could see at once on the Ordnance map that A was due east of B, knowing east to be 90°, we should know that the magnetic bearing of A from B was 90° + 15° = 105°.

DIP.

By the "Dip" is meant the tendency which the magnetized end of the magnetic needle has to point downwards. It varies all over the world. At the Equator it is almost imperceptible.

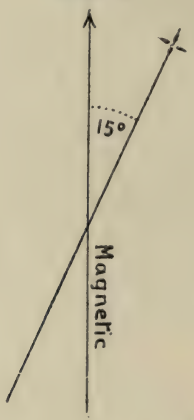
When the dip does become perceptible it may be counteracted by dropping a small piece of sealing wax on the compass card generally on the underneath side; in case of compasses with fixed cards underneath the needle, it must be dropped on the needle itself.

NORTH POINT.

On all military or field sketches, the true north and magnetic north are shown as in the accompanying conventional sign (Fig. 3); but it must be remembered it is not necessary for the arrow head to point to the top of the sketch; in fact, it may point in any direction; for instance, in making

a sketch of a road it is desirable to get the whole of the sketch within the limits of the paper and in order to accomplish this, the arrow head must point in the general direction in which the road runs, *e.g.*, if the road ran in an easterly direction, the north would be put in so as to point towards the left side.

Fig. 3.



The true north and magnetic north are always shown on every military sketch, and also one or the other on most maps in some shape or form ; and as the direction of true north never varies, this, enables anyone using a map or making a field sketch to, what is technically termed, "*set*" the map or sketch. To "*set*" it means to lay it out in the same position as the ground it illustrates, or is going to illustrate, so that the north point on it, actually points to the north, etc.

It also enables anyone to put several sketches together, though the sketches may have been made by totally different people ; the magnetic north varies in different parts of the globe, and at different times in the year (explained on pages 21—24). Ordnance maps have their vertical sides running due north and south and consequently

their top and bottom edges due east and west; whereas on military maps or sketches as before mentioned, the north point may be shown facing in any direction.

Another reason for this is as follows: military maps and sketches have to be consulted and studied frequently in the field, and if they were always drawn with the north at the top, the name of the place, etc., would be written so as to be read when held this particular way; this would prove awkward if the person using the map happened to be with a force moving south and wished to compare the ground to his front with the sketch or map, because he would have to hold it upside down, as regards the printing of names of places. So as a rule, military maps or sketches should be executed with the top edge facing in the general direction along which the force has to march, quite irrespective of the north point on the paper, and in many cases the north point may appear facing the bottom edge or one of the sides of the sketch, and so long as the whole map has been drawn with respect to the north point being fixed in this particular position on the paper, the map will be quite correct and the person using it will always be looking at it in the direction in which he is moving and can compare the surroundings with the sketch, noting conspicuous objects.

FINDING TRUE NORTH.

(*a*) *By means of the sun.*

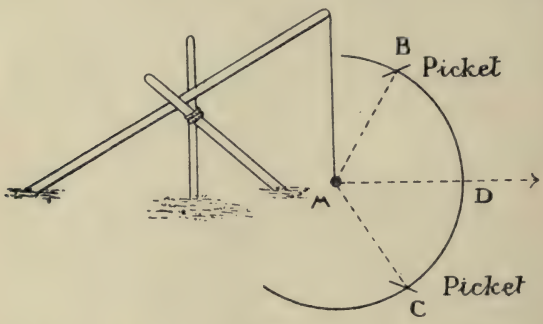
By day, in England, the bearing of the sun at noon is practically due south; the simplest way of finding true north is to fix a pole pointing towards the north, into a fork made by two sticks crossed and lashed together; to the end of this pole attach a plumb-line so that the weight just touches the ground as at A in the figure below; under this, the ground should be as level as possible. About half-an-hour before 12 o'clock the end of the shadow made by the pole should be marked with a picket, as for instance, point B, and with the point A where the plumb-line rests, as centre and with a radius to the picket B, describe a semi-circle. The shadow will gradually get shorter and shorter till 12, after this it will lengthen again and eventually

touch the semi-circle ; mark this point C with a picket, bisect the arc between these two pickets at D, and a line drawn from the centre of the circle A through the point D where the arc is bisected, gives the direction of true north.

By taking the bearing of the line AD, the variation of the compass may be ascertained, as explained before in this chapter.

(*b*) *By means of a watch.*

A rough method of *finding the direction of the north by day* in the Northern Hemisphere, is to hold a watch horizontally on the palm of the hand, face upwards, then point the hour hand of the watch at the sun, and bisect the angle formed by the hour hand and a line drawn through the



centre of the dial of the watch and the figure XII. This bisecting line then runs due north and south, the northern end being that running away from the direction of the sun.

In the Southern Hemisphere, the method is almost similar, the only difference being that instead of pointing the hour hand at the sun, you point the line from the centre of the dial to the figure XII at the sun ; then the bisecting line gives a north and south line, the southern end running away from the direction of the sun.

Note.—This method is a rough one. It should never be

used in the tropics ; the higher the latitude, *i.e.*, the farther from the Equator, the more reliable it is.

(*c*) *By means of the Pole Star.*

In England the direction of the Pole Star or North Star is practically due north, so, *by night*, a simple method of

Fig. 1.

Fig. 2.

finding true north is to hang a plumb line from the top of a window pointing northwards. As soon as the North Star is on the meridian (this is the case when ζ (zeta), the star second from the end of the tail of the Great Bear or Plough, is in the same vertical plane as the pole star (above it as in Fig. 1, or below it as in Fig. 2)), stick a pin on the window sill in line with the string and star ; the line joining pin and string gives the direction of the true north. The two stars, *a* and *b*, at the head of the Plough, are termed the pointers ; they always point to the North or Pole Star.

CHAPTER V.

INSTRUMENTS USED IN FIELD SKETCHING.

(*a*) THE PROTRACTOR.

The Protractor is usually made of boxwood ; it is six inches long and about one-and-a-half inches wide ; around the outer edge of the protractor, the degrees from 0° to 180° are marked from left to right, and below these, degrees from 180° to 360° are also marked from left to right. The inner edge has no degrees marked on it, but usually a scale of 4 or 6 inches to the mile ; the centre of this inner edge is shown by a star or an arrow head.

To Take Off a Distance.

The centre of the protractor on one side has a diagonal scale showing inches, from which decimal points of an inch can be measured. For instance if the length of a scale worked out to 5·7″, you would first measure the 5 inches and then add on ·7 from the diagonal scale, which shows an inch divided into tenths, ·7 being seven of these tenths. The diagonal scale has ten lines drawn parallel to and above the line, which is divided into inches, and the first inch of this line is subdivided into 10 equal parts and has 10 diagonal lines running from these 10 divisions to the top parallel line. By means of these lines, lengths in inches running to two decimal places (at 5·34″) may be measured, but it is quite sufficient for all military sketching purposes to take only the first decimal point (as 5·3″) measured as explained above. On one side of some protractors a scale which is known as a scale of horizontal equivalents is shown. The chief use a protractor has to a sketcher, in addition to measuring off lengths for the scale,

is that it enables him to "plot" or "set off" any angle from 0° to 360° from any given point in any given straight line.

To Lay Off a Bearing.

The method of setting off a bearing or angle with the protractor is as follows: —Place the inner edge of the protractor (*i.e.*, the one where no degrees are marked) immediately against the line from which you have to set off the angle, with the star spoken of above, immediately at the point in the line from which the angle is to be set off. If the angle is between 0° and 180° the protractor must be to the *right* of the line, *i.e.*, with its inner edge to the left or above it; if the angle is between 180° and 360°, place it on the *left* of the line, *i.e.*, with its inner edge to the right, or below it. At the place where the angle you require is marked on the protractor's edge, make a dot with your pencil point on your paper, then draw a line from the original point through this dot, and you have the correct angle or bearing.

(*b*) PRISMATIC COMPASS.

In military sketching the chief instrument used is the Prismatic Compass. This instrument consists of a round brass box about half an inch deep and three inches in diameter. On one side of the box is fixed a sight-vane, in the centre of which is a horse-hair or thin wire, and immediately opposite is a prism; the top of the prism has a V-shaped slit through which the hair can be seen. In the centre of the box is a pin, on which is balanced a magnetic needle, attached to a compass card which is fixed on the top of it; this card is divided so as to show degrees and half-degrees. In the lid of the box is a small opening immediately below the prism, so that when the sight-vane is directed on an object, the figures on the card are at the same time reflected, by means of the prism, through this opening to the eye of the observer. There are two peculiarities in the figuring of the card; they are: 1st, that the 360° is at the south end of the needle instead of the north for the following reason,

namely:—To bring the observed bearing under the prism, and have it reflected up to the observer's eye.

EXAMPLE.—A is an object north of the observer, consequently it would bear 360°, so if the reading of the card was not reversed, 180° would appear under the eye of the observer.

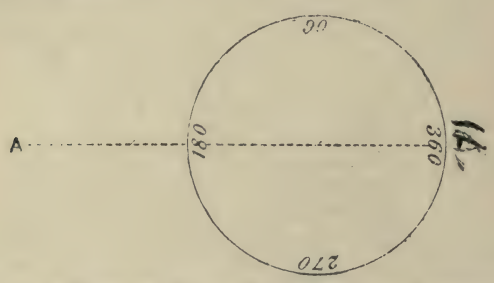


FIGURE SHOWING CARD WITH DEGREES REVERSED.

Secondly, the figures are inverted (put backwards), so that they may be reflected in their proper position through the prism, to the eye of the observer. Below the sight-vane is a small knob, which, if pressed, pushes a spring against the card, and so steadies it.

In event of the Service Prismatic Compass being placed in the hands of a N.C.O., a slight description is appended.

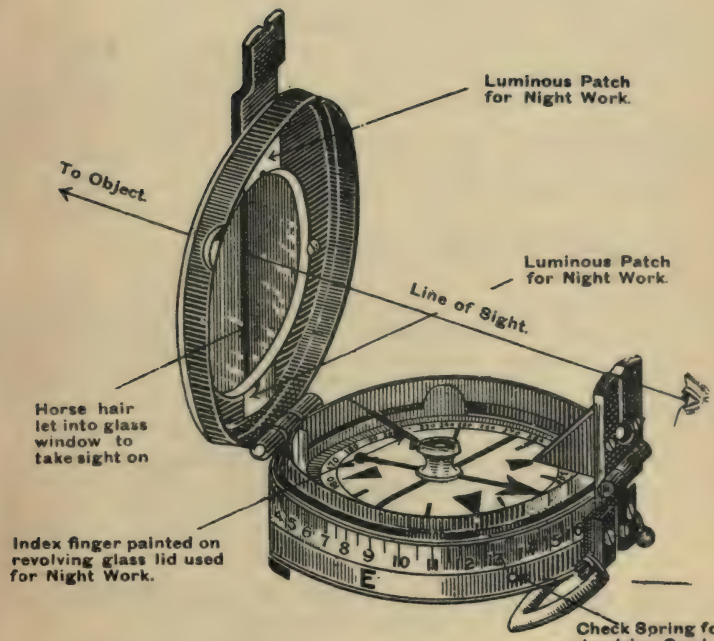
(*c*) SERVICE PRISMATIC COMPASS.

This compass differs from the ordinary Prismatic Compass in that it has a metal lid opening on a hinge; let into the lid is a glazed window with a hair line running through the centre, which does duty for a sight-vane. (See illustration Plate II.)

In case the glass smashes, small holes above and below the line are pierced in the metal, through which cotton can be threaded, as a substitute for the hair line.

There is a brass ring attached for convenience in holding and for a strap. The compass card has two sets of figures,

PLATE II.


Luminous Patch for Night Work.
To Object
Luminous Patch for Night Work.
Line of Sight.
Horse hair let into glass window to take sight on
Index finger painted on revolving glass lid used for Night Work.
Check Spring for steadying Card.

THE SERVICE LUMINOUS PRISMATIC COMPASS.

R.F.L.

one (the outer) for use with the prism, and the other set (the inner) is used for direct readings, as for compass marching.

This compass has special facilities for night work ; the card is luminous, and there are also two patches of luminous paint in the lid, one above and one below the horse-hair line. The north point is marked with a large black diamond-shaped figure and not covered with luminous paint, so that it will show up amid the surrounding paint.

For marching on a compass bearing, which must always be the case during a night march, there is a glass top which revolves and which has a black line (or index finger) on it ; the glass top is fitted over the card.

The outside of the box is divided into 72 parts showing divisions of 5° (*i.e.*, $5° \times 72 = 360°$), and each division of 10° is numbered 1, 2, 3, 4, etc., from north to east and south and so round.

The way to use the compass to march on a bearing at night is as follows :—

Set the index finger, referred to above, to the required bearing, as marked on the *outside* of the box. This is done by daylight. Then clamp the glass by means of a screw (not shown in figure). Then at night all that has to be done is to allow the card to steady itself, then carefully twist the box round until the black line (index finger) comes immediately over the diamond-shaped north point, when the luminous paint around will show it up ; then a line between the luminous patches on the lid gives the line of advance on the required bearing.

THE METHOD OF USING BOTH COMPASSES IS PRECISELY SIMILAR.

To take the bearing of an object, turn up the prism and sight-vane. Face the object, holding the compass level with the eyes with both hands, the card will revolve rapidly owing to the motion, check its swing by pressing the check spring when the card is mid-way in its swing. Look through the slit in the prism at the object, still keeping

the compass level; when the horse-hair is aligned accurately on the object, and the card has come to rest, the degree of the bearing will be reflected up into the eye of the observer.

The compass is practically useless either in the seen or unseen presence of iron, as was the case in South Africa.

Every magnetic compass has, as before said, a variation; this variation is continually altering slightly; at present, as before mentioned, it is about 15° west, in England.

This means that the needle does not point to the true north, but it points about 15° to the west of true north. This variation is termed *the magnetic variation* of the compass; see detailed explanation, pages 21—24.

The *advantages* of the prismatic compass are:

It is very portable and simple.

It is most useful for rapid work.

It is often useful in directing you as to your way.

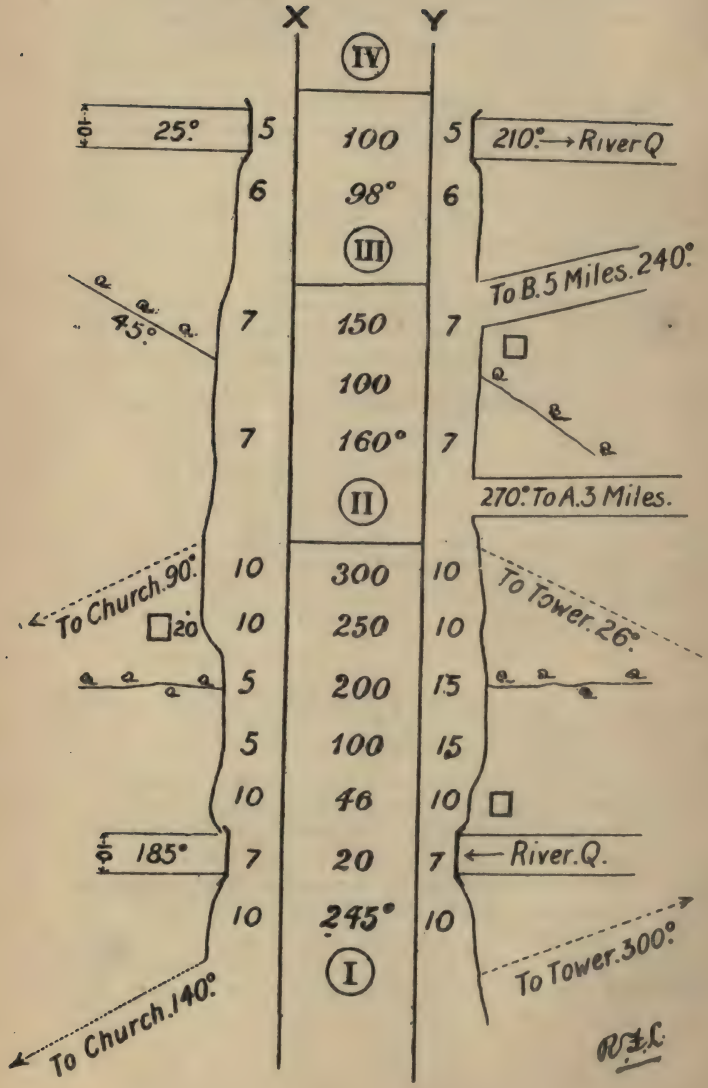
It is easily concealed if sketching in an enemy's country, and the Service Prismatic Compass enables one to march on compass bearings by night as well as by day.

Its *disadvantages* are:—

Cannot be used near iron.
It is very hard to use in windy weather.
It is not an accurate instrument.

Regarding the disadvantages stated above: the presence of iron is never great enough in England to make the compass err more than 2°; when using near a railway line, it is best to stand in the centre of the sets of rails, so as to have an equal amount of iron on either side of you; this neutralizes its effect on the compass; in windy weather it is best to kneel to get the observation, resting the elbow on the knee; and in the presence of troops armed with rifles the user of the compass *must* be at least 100 yards away from the men.

PLATE III.


X
Y
IV
III
II
I
25°
5
6
7
7
10
10
5
10
10
7
10
100
98°
150
100
160°
300
250
200
100
46
20
245°
5
6
7
7
10
10
15
15
10
7
10
210° → River Q
To B. 5 Miles. 240°
270° To A. 3 Miles.
To Tower. 26°
← River. Q.
To Tower. 300°
45°
To Church. 90°
20
185°
To Church. 140°
R.T.C.

CHAPTER VI

TRAVERSING.

For this a compass is essential.

This means sketching by means of a continuous series of measured straight lines, of which you take the direction or bearing with a compass at each change of direction, as you proceed. These lines are called *Traverse* lines, and the sketcher must pace actually along these lines. The detail is sketched in by means of *offsets* or cross-bearings. Offsets are measurements drawn at right angles to the traverse lines, and should seldom be longer than 100 yards.

Cross-bearings are bearings taken from the traverse line to fix by intersection the position of any required point which is beyond the limits of an offset.

Traversing can be carried out in two ways—

(1) By recording all observations in a field book and plotting them at leisure.

(2) By plotting the observations and filling in the detail as you proceed with the sketch.

Traversing is useful in forests or where the grass is very high and so the view limited, making it impossible to obtain the intersections of "bearings" taken to distant objects.

TRAVERSING WITH THE FIELD BOOK.

The field book is merely a note book with two parallel lines ruled down the centre of the page, about one inch apart, forming what is called the "chain column." In this column are entered all the forward bearings taken with the prismatic compass, also all forward measurements ; at the sides of the column are entered the various objects of importance on each side of the road.

At each different station a line should be drawn across the chain column, and each station marked either A, B, C, or I., II., III., surrounded by a circle, or in brackets thus :—(A), or (I.). (See Plate III.).

Plate III. shows part of a field book ready for plotting :—

To explain this extract.

First consider that the lines X and Y, with the space between them, which form what is known as the *chain column*, represent a line having no breadth.

The sketcher starts at (1), his first station on the road he is going to sketch. He takes a bearing along the road as far as he can see in front of him (this is 245° on above example), he notices a church to his left, and a tower to his right, he takes bearings to both of them (these are termed "cross-bearings"), 140° to church and 300° to tower, he intends to fix these positions by taking bearings back to them from another point further up road, the intersection of his future bearings and present bearings fixing the actual church and tower respectively. He now enters width of road from the centre to hedge on each side, this appears to be 10 yards; total width being 20 yards.

He then paces forward until he arrives at a bridge, and having paced 20 yards, enters those figures in the chain column; the width of road on either side of his traverse line here is 7 yards. He takes the bearing of the river (which is flowing to his left) in the direction of its flow, and finds this 185°; the width he enters as 10 yards. *Taking up the count from 20 yards*, he proceeds forward on his traverse line until he reaches a house on his right, after pacing 46 yards; he finds width of road 10 yards on either side here, and then paces on, taking up count from 46. Having paced 100 yards he finds the road swerves, but he has kept straight on his traverse line, so he enters width of road on his right 15 yards, on his left 5 yards. He takes up count from 100 and paces on until he reaches a hedge that cuts his road at right angles, at 200 yards. As he paces forward he sees the road swerves back again, and on arriving at a house on his left at 250, he is again in the centre of the road, and enters 10 yards on either side. He then takes up the count from 250 and proceeds as far as he can go on his traverse line. He finds that he has come to the end, when he has paced 300 yards, so he closes the column by drawing a line across it, but before starting in a new direction he takes the bearing of the tower on his right, 26°, and the church on his left, 90°.

At Station (II) he faces in the new direction and takes a forward bearing down the road as far as he can see on to some object in the distance, a tree, a house, or a post. He enters the forked road going off to A, bearing 270° on his right. He finds the forward bearing of his new traverse line 160°, and the width of the road 7 yards on each side. He paces on until he comes to a hedge that cuts the road at an angle; he finds the bearing of this hedge on his left is 45°, and it continues in a straight line in the same direction on the other side of the road. Having paced on to 150, he comes to a house on his right, which he enters together with the width of the road 7 yards on each side, and having come to the end of the traverse line, closes the column and starts at station (III), where he puts in the bearing of the road to B, 240°, and he finds his next forward bearing to be 98°. He paces on, and having gone 100 yards, he finds he crosses a bridge over the river Q again, and so takes a bearing down river to his right 210°, and to his left 25°, as the river swerves; there he stops at station (IV) which is half mile from the village of C.

PLOTTING THE TRAVERSE.

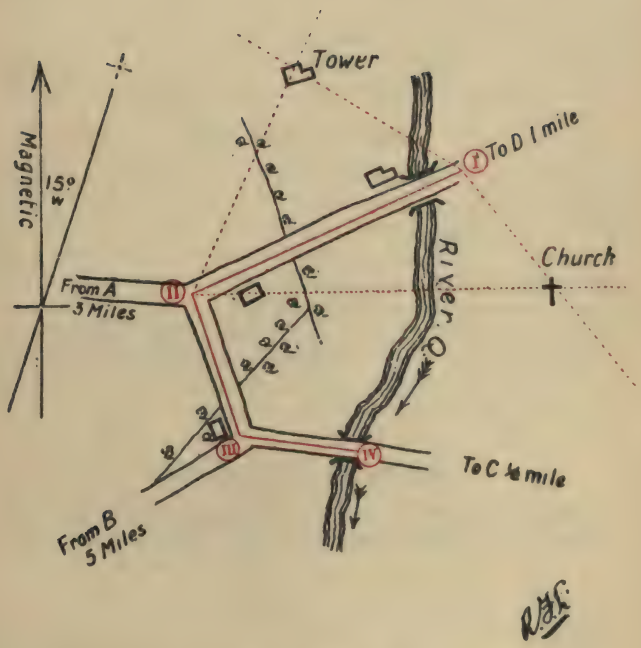
When the sketcher gets home he must transfer his observations, which of course are not drawn to scale, and which might be termed pictorial memoranda, to paper, and so form a proper sketch. To do this he first covers a clean piece of sketching paper with magnetic meridians (or magnetic north and south lines), which may be drawn in any direction so long as all are parallel. From any points on these lines he will be able to plot off his bearings and so get the sketch transferred to paper. As the sketch is a fairly long and narrow one, he draws, let us say, his magnetic lines straight up and down the paper with the top end marked N.

The reader may at first be puzzled about these magnetic meridians, as to the direction in which they are to be drawn; let him remember that they may be drawn in *any* direction, so long as they are all parallel, but as a rule a sketcher gets into his head, as he proceeds, a rough idea of the shape of the whole piece of ground he is sketching and its direc-

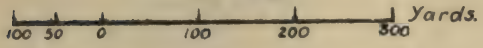
tion with regard to the north, and so he places his magnetic meridians and marks one end of them north in such a manner that will enable him *to get the whole of his sketch on to his paper.*

Plate IV. shows the observations recorded on Plate III. plotted. The magnetic meridians have been purposely omitted, as in a proper sketch they would only be put in, in pencil and rubbed out after the sketch was inked in, because their only purpose is to serve to plot off bearings (or angles with reference to the magnetic north). Traverse lines in red, other bearings in dotted red lines.

PLATE IV.



Scale 200 Yards to the inch
R. F. 1/7200.



CHAPTER VII.

PLANE TABLE.

The plane table is a portable table about 18 inches square and consists of a smooth board resting on a tripod stand ; there is a clamping screw underneath by which the table may be fixed in any position. When not fixed, the table can be easily turned round, or pivoted, on its centre.

THE SIGHT-RULE.

This is a wooden ruler with bevelled edges, at the ends of which are uprights, which are used for taking sights ; they resemble the prismatic compass sights, in that one contains a horse-hair and in the other there is a slit ; on the ruler between the uprights there are generally two or more scales. The sights of the ruler should be at least 6 inches high. In a hilly country where the line of sight is constantly at a considerable angle of elevation or depression, this is a matter of some importance, as the ruler of course lies quite level on the plane table when taking a ray.

THE TROUGH COMPASS.

This is a long narrow box which contains a magnetic needle. If a trough compass is unavailable the Service Prismatic Compass will do.

To use the plane table, place it where you intend to start work, and first of all see that it is quite level ; this is easily managed by moving the legs of the tripod. The table is next turned so as to get it in the required position ; in doing this, be careful that the whole sketch will come on the paper. Clamp the table by the screw underneath it and mark your starting point. Next place the compass on the table, and allow the needle to point to the magnetic north by moving box until needle points to centre division ; draw a line by the side of the box, and mark the magnetic north

point on it according to conventional signs; see Plate VII. The sketch may be *set* by the magnetic north and south line at any time by replacing the compass along it, and twisting the table until the line already drawn representing magnetic north and south is immediately under and parallel to the needle, which when steady points to the magnetic north.

The table being *set* and levelled, the actual sketch is commenced.

First, a base, or base line, is selected, this should be on level ground and should occupy a fairly central position; both ends of the base should be visible from well marked natural points in the area to be sketched, and from each other. Roughly, length of base may vary from ½ mile to 1 mile, depending on size of area to be sketched. Call one end of base (I.), and the other (II). Stick a pin in (I. and take the direction of (II.) from (I.) by pivoting the ruler against (I.) and directing the sight-vane on (II.). Then pace from (I.) to (II.), having drawn the line on your paper from (I.) in the right direction, this distance marked off to scale on your line gives position of (II.) on your sketch. Then, having *set* the table at (II.) either by means of the compass, or by means of the back station,* from (II.) take *rays*, as they are termed, to all well marked natural points, trees, hills, houses, etc., and draw lines from (II.) towards them; then from (I.) take rays to the same points, and the spots where rays taken to same points from opposite ends of base intersect, fix the positions of these points on your sketch. From the points thus obtained, other points may be fixed, the ground in the triangles thus formed being filled in by eye.

It is better, if working in a close country where stations are frequent, to *set* the table by means of the compass, than by means of the back station, as any error made when setting by the compass, though carried on, does not increase; whereas a similar error made in setting by the

*This means placing your ruler so that the edge passes through the station you have reached and also the last station you have come from, called the back station, and then pivoting the board and ruler on the station you have reached, turn the board until the ruler is directed on the back station.

back station is not only carried on, but increases at each station.

Another process for fixing points is termed *Resection;* this is the process of finding your actual place on the sketch; this may be done when you have a compass, and two points are recognised on sketch and ground.

Set the plane table with the compass, then, pivoting your ruler on one of the known points on the sketch, direct it at that point on the ground and draw a line through this point towards yourself.

Pivoting your ruler on the other point, direct it at the point it represents on the ground, draw a line towards yourself, the intersection of these two lines gives your position on the sketch. Numerous points may be fixed by resection, and so save the bother of pacing distances.

HINTS WHEN USING THE PLANE TABLE.

1. Always keep a very fine point to your pencil.

2. See that the leg-screws are taut before beginning work.

3. Spread legs of table as wide as possible.

4. When drawing a ray from a point, place the pencil just touching the point, and lay the ruler against the pencil.

SUMMARY OF THE PLANE TABLE.

1. It is a more simple instrument to manipulate than the prismatic compass, and consequently its use is much more readily learnt by N.C.O.'s.

2. It is more accurate and quicker to work with than the prismatic compass.

3. It gives you a comfortable table to draw on in the field.

4. It compels sketcher constantly to compare sketch with ground and thus assists in training a man to judge distance and appreciate general lie of a piece of country.

5. Work can be done in localities where the presence of iron would render results from a magnetic compass practically valueless.

6. Its chief drawback is, that it is an awkward thing to carry about in the field.

CHAPTER VIII.

EYE SKETCHING.

By eye sketching is meant sketching without the help of any instruments except a board, paper, pencil, and a flat ruler.

Make a scale to suit the sketch by dividing a line into any number of equal divisions each to represent a 100 yards and of a suitable size to get all the sketch on the paper.

The principles of eye sketching are much the same as those of the plane table; the sketch has to be *set* in eye sketching just as much as when using the plane table, but in eye sketching the only means of setting it is by the back angle.

The term "setting the sketch by the back-angle," may seem to indicate to a beginner some complicated process, whereas in reality it is a very simple method. It consists merely in placing your ruler on your sketch *on a line*, joining two stations, the distance between which you have just paced, then twisting sketch without moving ruler, until edge of ruler is in a line with the road between the station you have *arrived at*, and the other station which you have just left. Supposing, for instance, you start at a lamp-post in the middle of the road, and pace along the road till you arrive at a tree, having drawn in the road from the lamp-post to the tree, you place your ruler with its edge along the line representing this piece of road on your sketch, and twist your sketch round until the edge of the ruler is aligned on the lamp-post, and the sketch is set.

Having drawn the scale, lay the sketching case and paper on the ground, mark station (I.) on the sketch, and align the ruler on station (II.); to see that the ruler is properly aligned, hold a plumb-line a few paces behind it and see if the edge of the ruler corresponds with the line; if so, draw a line along the edge, if not, move the sketching case until it does coincide. Then align the ruler on any objects on each side, which are required in the sketch, but without moving the sketching case; the positions of these objects

will be fixed by lines intersecting, drawn from another station. Next pace the distance to station (II.) and mark it off according to scale, along the line which has already been drawn from station (I.) towards (II.); this fixes the position of station (II.). Now place the ruler along the line from station (I.) to (II.) and move the sketching case, not the ruler, until the ruler is in line with No. (I.) station, this sets this sketch; then pivoting the ruler on No. (II.) station, this time without moving the sketching case, align it on a new station No. (III.) and proceed as from station (I.). Before leaving station (II.), align the ruler from station (II.) on any objects which were seen from station (I.), and draw lines to them and where these lines intersect the lines drawn to them from station (I.) on the sketch, will give in each case the positions of these objects on your sketch.

An approximate *true* north point may be put on the sketch, when you have set it at any time by means of the back angle, by placing sketch so set, on level ground and marking on it the direction of the shadow of a plumb-line held alongside it at midday.

N.B.—Try particularly to establish at the outset, as long a base as possible, and one from the ends of which well-defined objects can be seen.

Eye sketching may in reality be defined as plane tabling without a compass and without a tripod stand for the board.

COLOURING SKETCH.

Should there be time, it is advisable to colour the sketch; if paints are not used, chalk pencils will answer the purpose. For example see Plate V.

Villages and houses should be shown in black; roads outlined in black, metalled roads may be coloured brown; rivers and ponds that have water in them at the time of sketching, both outlined and filled in, in blue; woods, green; contours, burnt sienna; railways, a broad red line, or black line crossed at intervals by small lines, at right angles to the main line; entrenchments and British troops in red.

PLATE. V.

Scale 6 Inches to a mile.

R.F. 10560

100 50 0 100 200 300 400 500 600 700

R.T.L.

CHAPTER IX.

CONTOURS.

The definition of a contour is :—

" The outline of a plane surface of a hill, which is exposed when the hill is cut or intersected by a horizontal plane."

Call to mind any fairly pronounced sugar-loaf shaped hill in your district, imagine a large piece of the top sliced off as with a knife, the blade of the knife moving parallel to the surface of the sea. Lift off the top thus sliced and you expose a plane surface ; the outline of this surface, all round the edge, would represent a contour line.

Contouring, which is used on all military sketches and maps, is a method of showing the shape of hills in a plan, and these contours are imaginary lines running round a hill ; and the whole way round each individual contour at any point in it, is exactly the same level above the sea ; on a sketch, contours or *form lines*, as approximate contours in military sketching are termed, are usually shown by thin lines drawn in brown colour—they may also be coloured red in military maps, and in fact red was the usual colour some time ago, but now brown is considered the best colour to use for this purpose.

The height of hills is also indicated by the contours on a map. The height of one contour above another, commonly called the vertical interval (V.I.), is always a certain fixed number of feet, which is the same throughout in any one map.

Example.—If on a map, a hill was represented by six contours, and the V.I. was 20′, it is quite clear that the hill must be higher than 120 feet and lower than 140 feet. It might be 121 feet high, or anything up to 139, but it could not be 140, or there would be seven contours shown, *e.g.*, see Plate VI., where there are five contours shown ; if the vertical interval was 20 feet, the hill must be more than 100 feet high and less than 120 feet.

Another use of the contour is that, it indicates the slope of the ground, showing whether the slopes of hills are gentle or steep. The nearer together two contours appear on a map (*i.e.*, in plan) the steeper the slope, and *vice versâ*, as may be seen by a glance at Plate VI., which represents a plan of a small hill, and a section through A.B. Slope from A to C is gentle and contours in plan far apart. Slope from B. to D. is steep and contours in plan near together.

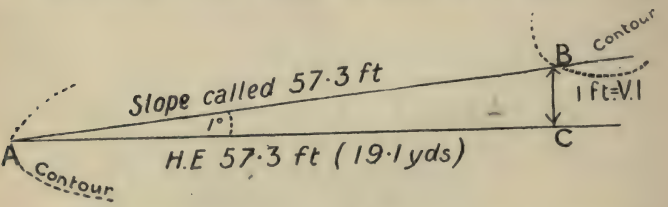
EXPLANATION OF HORIZONTAL EQUIVALENTS.

We must next take into consideration the distance on the ground, *i.e.*, in plan, between two adjacent contours. This distance is termed the Horizontal Equivalent (H.E.).

To explain this term we must first get into our minds the fact that the V.I. being a fixed quantity on any one map, the H.E. *will vary* according to the steepness of the slope, as explained in the previous paragraph. Therefore, the Horizontal Equivalent means the distance (usually expressed in yards) which is the equivalent *in plan* for a certain degree of slope at a certain V.I.

THE TRIANGLE OF REFERENCE.

It has been calculated by experiment that one would have to move a distance of 57·3 ft. horizontally up a slope of 1° before one would have risen 1 ft. above one's starting point. On this fact the whole system of contouring is based.



The triangle A B C is termed the "triangle of reference" B C is the Vertical Interval (1 ft.), A B is the slope up which we will imagine we have to walk, and B A C = 1°.

Now the V.I. being 1 ft. in this case, a contour passes through A and the next through B. If we were looking

down on to the slope A B from a balloon immediately above it, and so getting the appearance of A B as in plan or on a map, the length of A B in plan would only appear as the length A C ; so for military sketching, where extreme accuracy is unnecessary, we assume A B is equal to A C ; in reality the difference between them in length being so small as not to matter. If we were dealing with extreme slopes over 20°, the difference would be considerable, but as we seldom come across anything steeper than 15°, the assumption is reasonable.

From this triangle of reference we obtain the formula,

$$\text{H.E.} = \frac{\text{V.I.} \times 19{\cdot}1}{\text{D}} \text{ yds.}$$

which from looking at the triangle we see only means

$$19{\cdot}1 = \frac{1 \times 19{\cdot}1}{1} \text{ yds.}$$

or $19{\cdot}1 = 19{\cdot}1$ (which is a fact).

From this formula, if we are given the degree of slope and the V.I., we can calculate the H.E.

e.g., a slope is 10°, and the V.I. is 50 ft.

$$\text{H.E} = \frac{50 \times 19{\cdot}1}{10} = 95{\cdot}5 \text{ yds.}$$

The essential point to realise from all this is as follows :— If we start from a point A and move to a point B, distant 95·5 yds. up a slope of 10°, when we have arrived at B we are 50 ft. higher than A.

So, when out field sketching, we take the degree of slope either by means of a clinometer (an instrument for measuring slopes) or a plumb-line fixed to our protractors (explained later), knowing the V.I. we are working to, we can calculate the H.E., and pacing this distance up (or down) this same slope we know we have risen (or dropped) one contour and can put it in our sketch, tracing it round by eye.

A CHANGE OF SLOPE BETWEEN TWO ADJACENT CONTOURS.

Now, should the degree of slope change before we have completed pacing the H.E., it is a simple matter of pro-

portion to fix where the next contour comes, and all depends on how much of the H.E. we have paced before the slope changes; if we have paced one half we must only pace half of the H.E. for the new slope; if we have paced one-third we must pace two-thirds of the H.E. of the new slope before we will have risen one contour and so on.

e.g., the first slope taken up a hill is 10°; V.I. = 50 ft.

$$\therefore \text{H.E.} = 95 \text{ yards (roughly).}$$

After pacing 47 yds. the slope changes to 5°. New H.E. is 190 yards.

As we have paced half the old H.E. (*i.e.*, 47 yds.) we must now pace half the new one, *i.e.*, 95 yards more, before we shall have risen one complete contour.

Protractors usually have scales of H.E. worked out on them for various degrees and various V.I. to save the sketcher trouble.

A METHOD OF TAKING THE DEGREE OF SLOPE.

Without a clinometer (which non-commissioned officers seldom possess) we can roughly estimate a slope in the following manner:—Take the protractor and fasten with a drawing pin one end of a piece of string about 12 inches long, to the arrow head or star which is in the centre of the edge which has no degrees marked on it. Tie a small weight to the other end, making it a plumb line, hold the protractor with the arrow head edge upwards and its long edges parallel to sea level. Allow the plumb line to swing freely against the surface of the protractor; when it is steady the string will cut the degree marked 90° which is opposite the arrow head or star. To take a slope, tilt the edge of the protractor, by eye, until it assumes the same slope (*i.e.*, is parallel to) up (or down), as the piece of ground you are sketching; this string will now pass through a point which is a certain number of degrees away from 90°, varying according to the steepness of the slope; count the number of degrees which it is away from 90° and this will give approximately the degree of slope required.

A ROUGH METHOD OF CONTOURING WHEN FIELD SKETCHING.

Having fixed your base and from its ends fixed by intersection of bearings or rays (before explained) a number of what are termed "*ruling points*," *i.e.*, conspicuous points at the tops of spurs, the bottoms of valleys, etc.; having filled in the detail by eye, it is now time to contour.

The sketcher will find it simpler to proceed to the highest ground in the area to be sketched and from there to select a number of what are termed *section lines*, *i.e.*, lines down which he intends to pace. These lines should run down the centres of spurs and valleys or along roads and paths. Pacing down the first section line, he will take the slope as he goes and, ascertaining the H.E., he can put in the contours as he reaches each successive point where a contour would cut the section line at right angles, and trace them on his paper by eye; he will then proceed to the next section line, and he might work up this one and down the next and so on.

He must take care to number the contours correctly so that he can join up contours of the same level from section line to section line as he goes on.

REFERENCE POINTS.

It is useful when at either end of the base at the start of a sketch, to note by means of a clinometer, or by aligning a ruler, any points which are at a distance away but on the same level as that on which the sketcher is standing; these come in useful later on, during the process of sketching, as when he arrives at one of these reference points the sketcher knows the level he is at as compared with his base line.

TO ASCERTAIN GRADIENT.

To find the gradient of the slope of ground between any two contours, all you want to know is, what is the V.I. and what is the scale of the sketch or map; if the V.I

be 20,' and on measuring the distance between the two contours from the scale, we find it is 100 yards, the gradient of the slope is then $\frac{20}{100\times3}=\frac{1}{15}$.

A rough way of bringing a gradient to degrees, which is fairly approximate if the gradient is not steeper than $\frac{1}{4}$, is to multiply the gradient by 60.

e.g., gradient of $\frac{1}{4}=\frac{1}{4}\times60=15°$* ; and gradient of $\frac{1}{15}=\frac{1}{15}\times60=4°$.

Again, by the help of contours, the visibility of points or the fact that one point can be seen or not from another, is determined. All the above-named points are most useful in arranging for the manœuvring of troops, on ground of which you have maps, or military sketches.

Heavy waggons cannot go up a slope steeper than 8° (*i.e.*, gradient $\frac{1}{7}$) without extra horses, and guns can go up 15° for short distances only, and with the greatest difficulty ; by remembering this it may act as a rough guide to estimate various slopes.

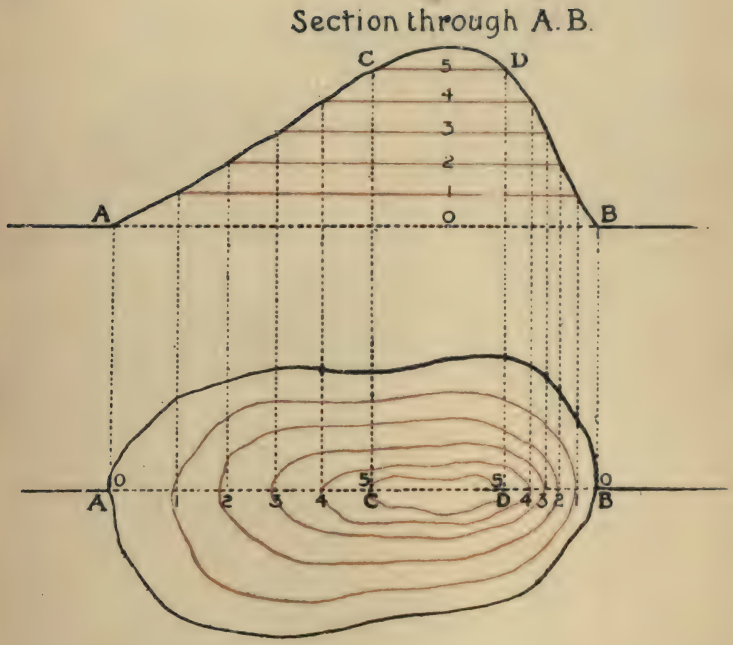
To ascertain the highest hill on a contoured plan, the lowest piece of country must first be found ; this will be discovered by following the course of the rivers ; where the biggest river runs off the map, the direction being noticed from the arrow which indicates a river's course, will be the lowest point, and the contour cutting the river nearest to this point will be the lowest contour ; count from this contour upwards and the top contour you come to will show the highest hill ; multiply the vertical interval between the contours by the number of contours, this will give the height above the lowest point on the map, which is quite sufficient, as you only want to know the relative heights of the various hills on your map, with regard to one another, their actual height above sea level does not matter.

EXAMPLE.—Suppose the vertical interval to be 20 feet, the number of contours from the lowest one to the top of hill (A) to be 8, to top of (B) to be 12.

---

* It should be remembered that 15° is the extreme limit of slopes admitting of manœuvres. Between 15° and 30° Infantry and Cavalry ascend and descend singly, the latter with great difficulty. Slopes over 30° must be climbed.

PLATE VI.



Plan

R.E.C.

Hill (A) would be 160′ higher than the lowest piece of ground on that map.

And Hill (B) would be 240′ higher than the lowest point.

N.B.—Contours on ordnance maps are figured according to their heights above mean sea level.

CHAPTER X.

MAP READING.

By map reading is meant the art of being able to grasp the topographical features or general run of a piece of country, from an inspection of a map representing the same.

As map reading forms now such an important part of a non-commissioned officer's course of instruction, we will go into this subject a little deeper.

The first thing to tackle in reading a map is the scale, as the scale of a map is the first thing that should be looked at. Grasping the scale and getting into your mind's eye so to speak, what the actual length a mile is on the map, enables you to realise at once the various distances of places from one another. We have gone into the construction of scales early in this little work, so we can presume that a knowledge sufficient to understand a scale has been acquired.

Having noted the scale, we now look for the north point; on ordnance maps the sides run true north and south, the top end being the north; with military maps the magnetic north is shown by a line with an arrow head, and the true north by a line with a star at the head.

The next thing we must discover is, what is the vertical interval (V.I.), or height of one contour above another. This enables us to realise heights of features shown on the map.

On ordnance maps the V.I. is found by noticing the figuring of the contours. Military maps usually have V.I. stated at the foot.

We must then be thoroughly conversant with certain signs which represent various things on maps. These signs are called "conventional signs." Plates VII. and VIII. give full descriptions of these signs.

CONVENTIONAL SIGNS USED IN FIELD SKETCHING

Reproduced from the "Manual of Map Reading and Field Sketching," by the permission of the Controller of His Majesty's Stationery Office

PLATE VIII.

SYMBOLS USED ON THE 1 Inch & 6 Inch ORDNANCE MAPS.

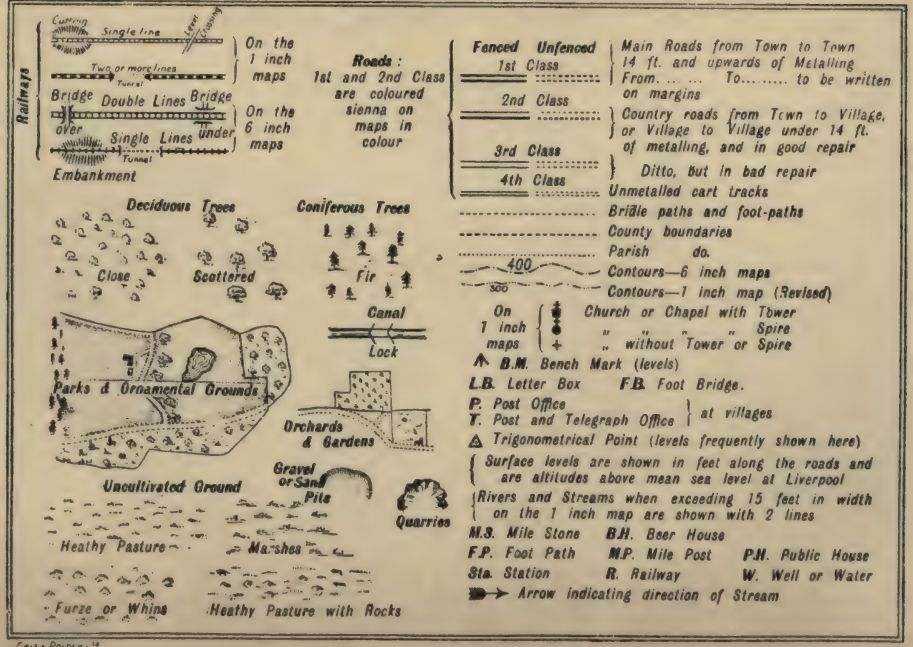


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Plate VII. gives those conventional signs which are to be used in field sketching alone.

Plate VIII. gives the conventional signs in use in ordnance survey maps. In some cases the signs for the same things are quite different in the two plates, and care must be taken not to get confused between the two.

The reader will notice for himself the difference between those used on the ordnance map and those used in field sketching; a study of the two plates will enable him to grasp the meaning of the various signs as shown.

ORDNANCE MAPS.

A point that might have special attention directed to it is as follows: a parish boundary, a county boundary, and a footpath are very similar in appearance, and so care should be taken not to mistake one for the other on ordnance maps.

The roads on ordnance maps, as may be seen from Plate VIII, are divided into four classes to indicate accurately their military value.

First-Class Roads are shown by two thick parallel lines, and thus indicate that the metalled portion (or artificially prepared surface), is over 14 feet wide, and will take, easily, two lines of traffic passing each other in opposite directions.

Second-Class Roads are shown by two parallel lines, one thick and one fine, and indicate the metalled portion to be under 14 feet.

Third-Class Roads are shown by two fine parallel lines, and are generally unfit for continuous heavy traffic, such as that of guns or military waggons.

Fourth-Class Roads are shown by two fine parallel lines, only they are drawn closer together than in the case of third class roads; these are unmetalled tracks, green lanes, etc.

When a road has anything raised at its sides which prevents troops from moving from off the road on to the

ground at the side, though this obstruction be a ten feet brick wall or a two feet high ordinary hedge, it is called a "*fenced*" road; when there is nothing raised to prevent troops moving from the road to the ground at the sides it is called an "*unfenced*" road. A "*fenced*" road is shown according to its class, as above, by continuous straight lines; an unfenced road by dotted lines. A road may of course be fenced on one side and unfenced on the other. This sign is used also in field sketching.

To explain the terms "deciduous" and "coniferous" trees, as used on Plate VIII., deciduous indicates such trees as shed their leaves in the autumn, leaving their branches bare during winter, whilst coniferous indicates "pines" and others of this class that give just as much cover from view in the winter as in the summer; it is important in manœuvring in winter from a point of "cover" to know whether trees are deciduous or coniferous. These signs are not used in field sketching.

MILITARY SKETCHES.

In making a Military Sketch it is well to write the word "*Marsh*" in addition to the conventional sign, and such terms as "*Heather*," "*Gorse*," *etc.*, should be entered on the sketch where they occur on the ground. Crops should be noted, their nature and height above ground being mentioned.

Churches are shown in three different ways in order to signify their value as signalling stations or points where good observations can be made with telescopes. It is presumed that a church with a tower is accessible as a signalling station, whilst one with a spire or a chapel would not be so. This is also the manner adopted on ordnance maps.

Streams and rivers are shown by a single blue line when less than 15 feet wide, and by double blue lines, coloured blue in between, when over that width. They are easily distinguishable from roads even if uncoloured, owing to the irregularity of their shape; their course is indicated by an arrow pointing in its direction.

In the case of woods, it should be noted in writing whether they are passable for troops of all arms or not; their nature, fir, oak, etc., should also be stated.

The first use of a map is to enable one to find one's way about in a strange country; to do this we must recognise points on the map and on the ground, and then endeavour to fix one's exact position on the map.

To use a map properly we must first—what is technically known as—*set it.*

To find your own position on the map is then an easy matter, the process of doing so is termed "Resection," and although we have already touched on this under the chapter on the Plane Table, page 41, we will now go a little more thoroughly into the process.

First let us see how to *set* a military map and an ordnance map, both with and without a compass in our possession.

SETTING THE MAP.

This means to lay it out in the same position as the ground it illustrates so that the north line on it points to the north, etc. The object of setting it is to enable one to identify on the ground the various points or localities shown on the map.

TO SET MAP WITH A COMPASS.

(*a*) On a Military Map.—Ascertain the position of the magnetic north on the map; this is always shown. Place the compass on the map, allowing it to rest, until needle is steady, then raise the compass carefully and twist the map round until the needle of the compass is parallel to the magnetic north line on the map, and the arrow-head pointing in the same direction as the magnetized end of needle. The map is then set, and by noticing anything prominent on the ground coinciding in description with what is marked on the map the sketcher can find his position approximately.

(*b*) On an Ordnance Map.—First with your protractor lay off an angle of 15° from any point on the left or western edge of the map, as explained on page 31, this will represent the magnetic north ; then place the compass over this, letting it rest till needle is steady, raise the compass, twist the map round till the line you have drawn representing magnetic north is parallel to the needle, etc., as above. Map is then set.

WITHOUT A COMPASS.

Two points must be recognised on map and ground.

(*a*) **Your own position and another point.** Place your ruler so that the edge runs along a line joining the two points, then pivot map (and ruler) on your position, twisting until ruler is directed at the distant point. Map is set.

(*b*) **Two other points** (neither being your own position). You must either get in between, that is, on a line joining these two points or in prolongation of a line joining them ; then place your ruler on a line joining them on your map, and pivot map and ruler so that the two points on map and the two on ground are all four in the same straight line. Map is set.

RESECTION.

Having thoroughly gone into the process of setting the map, we will now explain the method of fixing your position on it.

(*a*) The method of doing this *when you have a compass* has already been dealt with on page 41. The map is set by means of the compass and two points must be recognized on map and ground, rays are drawn from the points on the ground, through the points on the map, the point of intersection of these rays being your position.

(*b*) *Without a compass.*

The "method of adjustment" is a rough and ready way of resecting without a compass. All you want is a piece of trans-

parent paper, tracing paper, or ordinary paper dipped in hot grease and dried. You must first recognize three points on map and ground. Place the piece of transparent paper on a level surface or on the ground, mark a point on it anywhere near the centre; this point will represent your position. From this point without moving the paper draw rays to the three recognized points on the ground. Take up the paper, place it on your map over the three recognized points and twist it about so that eventually you get the three rays to pass through the three points on the map, to which the rays were drawn respectively. The lines may have to be prolonged in order to get this result, but this may be done for any length. Having twisted paper until this result is obtained, then *prick through on to the map the point you originally took on the tracing paper to represent your position, this gives you your position on the map itself.*

SHADING HILLS.

Some maps, in addition to being contoured, are shaded; the object of shading them is to develop the features of the ground and make them stand out in relief, as it were, so that the hills and valleys may be recognized at a glance. It is a little difficult for beginners to distinguish at once these features from an inspection of the contour lines alone, and the shading is therefore of great assistance to a beginner in map reading.

There are two systems of shading maps; the first is known as "hachuring" and consists of covering the ground over the contours with a number of fine pen-strokes, called "vertical hachures" (either black or burnt sienna-colour). These strokes are drawn thick and close together to represent steep slopes, and thin and far apart to indicate gentle slopes. This system is carried out in many small-scale (1-inch) ordnance maps of the United Kingdom, India, etc.

The second method, known as "shading in mezzo-tint," or "stumping," is never found on printed maps and is only used in military sketching. It is easier to execute than

hachuring and is equally effective, the principle of using dark shades for steep slopes and light shades for gentle ones being adhered to.

In both systems the highest summits are left white and the hill-sides alone are shaded; any flat country, whether high or low-lying, is left unshaded, but the low-lying is generally easily recognized by the presence of streams or water in other forms.

MAP READING ON THE GROUND.

It is an exceedingly useful practice when studying map reading, after having mastered the various methods and artifices used in making maps, to take out large and small scale ordnance maps on to the ground, and compare the maps with the actual country they represent.

Two methods of study should be alternated:—

(*a*) Examine the map carefully in detail for some time, say 10 minutes, and get thoroughly into your mind's eye what it conveys. Then look at the country and compare it bit by bit. Use a scale, so as to get distances between objects; note the general form of the ground as portrayed on the map, the direction of valleys and spurs, relative heights, steep slopes, flat ground, probable dead ground, woods, etc.

(*b*) Have a good look at the country first. Judge distances and heights. Endeavour to convert in your mind distance into inches, according to the map scale, thus trying to imagine what the map would look like. When you have got some idea of this, turn to the map and compare.

CHAPTER XI.

VISIBILITY OF POINTS.

No work on map reading, however elementary, could be complete which omitted the question of the visibility of points.

It is a question most frequently recurring in map reading as to whether one point on the map is visible from another.

It is obvious that in open country (devoid of hedges, walls, trees, etc.) two points are visible from each other, when no physical feature obstructs the vision or line of sight from one to the other; *e.g.*, two points on opposite sides of a valley will be visible, if both are higher than any portion of ground between them. It is also obvious that, on an open plain which is level, or on a slope which is uniform, not only will any two points be visible from each other, but the intervening country will be visible from either point.

Let us see the extent to which the visibility of one point from another, and of the intervening ground, can be ascertained from a sketch or map. First, join the two points in question with a straight line in pencil. Now follow the contours that cut this line and see how they run. If it is simply a question of the slope between the two points being a steady *continuous* slope running up or down the side of the hill, then the question is simple; if, on the other hand, we see by the contours that the ground falls so many feet, rises again and then goes down again, we can then see it is a more difficult matter; we have an *interrupted* slope or a piece of ground intervening, then it becomes a question whether this piece of intervening ground is sufficiently high to interrupt the line of sight from one point to the other; if it is so, then the points are not visible one from the other; if it is not so, then they are.

The whole question of visibility of points then resolves itself into this: is the *general section* of the ground between

the two points concave or convex? If it is concave, the two points can be seen from one another; if convex, they cannot.

The slope between two points is concave when an imaginary straight line joining them is throughout its length above the surface of the ground immediately beneath it, and convex when the surface of the ground interrupts the direct vision between these points. It may be noted that a convex slope is ill-suited for defence.

Next, to explain what is a *section* of a piece of ground or of a hill; it is the outline of the surface that is exposed when the hill or ground is cut by a vertical plane.

To illustrate this, take an apple, cut it in half, place one of the halves with its flat surface downwards on a table; assume this represents a hill. Stick two pins into this half at any two points, take a knife, hold it so that the blade is vertical and edge downwards; place edge so that it touches or is in line with the two pins, cut vertically downwards through the apple on to the table, remove the part cut off, and you expose a section between the two pins, and the outline or skin of the apple between the two pins shows the shape of the section, when held on a level with the eye.

CONTINUOUS SLOPES.

Let us first deal with *continuous slopes*. Supposing we see by the contours which cut the line joining the two points, that the ground steadily falls; for instance, the V.I. being 20 feet, the numbering of the first contour cutting it may be 260, the next 240, then 220, and so on, always falling. Now we want to know if the general section is concave or convex.

It must either be concave, convex, or a straight line (*i.e.*, slope uniform throughout).

If the contours cut the line *at fairly equal* distances apart, it is then known at once that the degree of steepness of the slope is the same throughout or uniform, and the section is a perfectly straight line, there is nothing to inter-

PLATE IX.

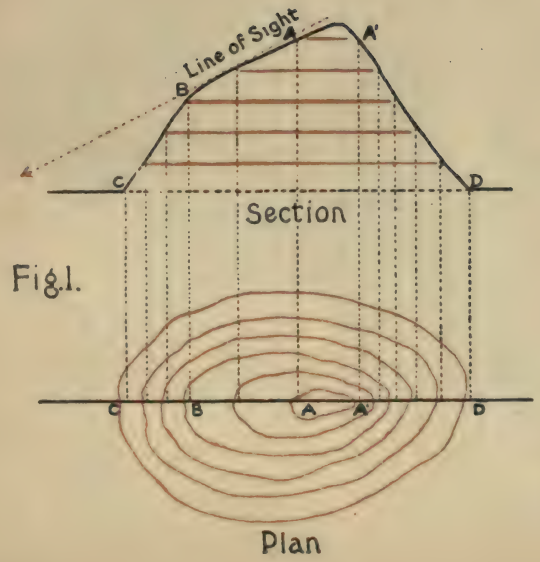


Fig.1.

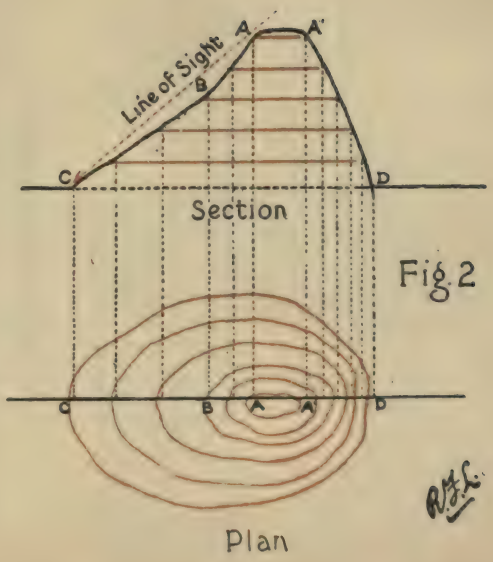


Fig.2

rupt the line of sight, therefore points are visible to one another. See Figs. 1 or 2, Plate IX. The slope from A to D is uniform, note contours in plan.

Starting always from the higher of the two points, if the contours are close together at first and then get farther apart, it means the ground falls steeply first and then gets gentler; therefore the general section is concave and the points are visible to one another. Note slope from A to C, Fig. 2, Plate IX., contours in plan from A to B are close together and from B to C farther apart.

If, on the other hand, the contours are first wide apart and then come closer together, it means the ground first falls gently and then becomes steeper; therefore general section is convex and the points are not visible to one another. See slope from A to C, Fig. 1, Plate IX., contours in plan from A to B far apart, and from B to C closer together.

INTERRUPTED SLOPE.

The first thing to ascertain is, which is the highest intervening point between the two points in question. Number the contours according to their height above sea level, or above lowest contour on map, as they cut the line joining the two points on the map; ascertain from this which is the highest intervening point. Let us take A and B as two such points. Now we wish to know whether they can be seen from one another or not—we find the highest contour of the intervening ground cuts the line joining them at C.

If we turn to Plate X., Fig. 1, we have a plan of an island of hilly ground and above the plan we have a section on the line X Y which runs through the island, cutting hills A, C and B. We number the contours in plan at the places where the line joining A to B cuts them, and to do this we start numbering from where the line X Y cuts the lowest contour next to sea level, calling sea level 0.

In Fig. 2, we have a plan and section of another island with three heights A, B and C, only the shape of the ground is different.

In both islands A is 300 feet above sea level, B is 100 feet, and C is 200 feet. Now if the reader will take the trouble to draw three vertical lines, one 3 inches long (to represent height of (A), one 2 inches (C), and one 1 inch (B), and place these three lines on the same horizontal level, he will at once see that it depends upon the distances between A and C and between C and B whether A is visible to B or not. *Vide* illustration, Figs. 1 and 2, Plate X.

In Fig. 1, looking at the section on X Y, we notice that from A to C is a more gentle slope than from C to B, therefore general section is *convex* and points are not visible one from the other.

In Fig. 2, looking at section on X Y, the slope from A to C is steeper than from C to B, therefore A is visible to B, the general section being *concave.*

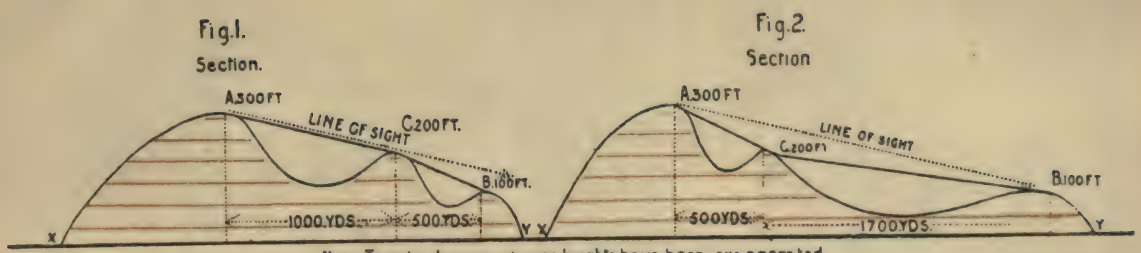
As we have only the map or plan to deal with and no sections to show us so simply whether the general line of sight is concave or convex, so the method of finding out whether the two points are visible or not from an inspection of the map, in such a case is as follows :—

Take the gradient of the line of sight from the higher of the two points to the intervening point, and compare it with gradient of the line of sight from the intervening point to the lower of the two points. If the former is the steeper gradient of the two, the general section is CONCAVE *and the two points are visible to one another; if, on the other hand, the former is the gentler gradient of the two, the general section is* CONVEX *and the points not visible to one another.*

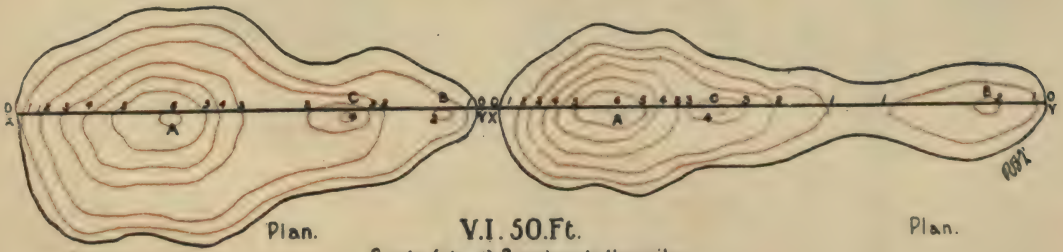
Take as example, Plate X. Fig. 1 (looking at the plan or map which of course in reality is all we should have to judge from).

From A to C it drops 2 contours and the V.I. is 50 feet —this means 100 feet drop; the distance from A to C measured on the plan or map from the scale is about 1,000 yards.

PLATE X.



Note. To make diagram plainer heights have been exaggerated.



Plan. V.I. 50.Ft. Plan.

Scale (about) 2 inches to the mile.

Therefore, the gradient from A to C is

$$\frac{100 \text{ ft.}}{1{,}000 \text{ yds.}} = \frac{\overset{1}{\cancel{100}}}{\underset{10}{\cancel{1000}} \times 3} = \frac{1}{30}$$

Now—

The drop from C to B (Fig. 1 plan) is 2 contours and equals 100 feet.

The distance from C to B measured on plan or map = 500 yards.

$$\therefore \text{ Gradient } = \frac{\overset{1}{\cancel{100}}}{\underset{5}{\cancel{500}} \times 3} = \frac{1}{15}$$

Anyone can see that $\frac{1}{30}$ is a more gentle slope than $\frac{1}{15}$.

Therefore the gentler slope being first, the general section is *convex* and the points invisible, as may be seen by the dotted line with arrow-head representing line of sight, which passes right over B (in Fig. 1 Section).

In Fig. 2 (Plan)—

We have a drop from A to C of 100 feet, distance on plan 500 yards.

$$\therefore \text{ Gradient } = \frac{100}{500 \times 3} = \frac{1}{15}$$

Drop from C to B = 100 feet.

Distance in yards = 1700 yards.

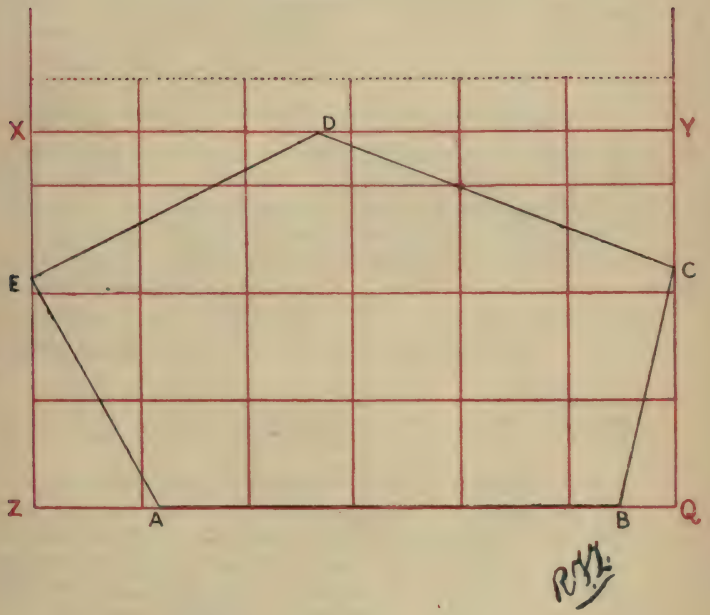
$$\therefore \text{ Gradient } = \frac{100}{1700 \times 3} = \frac{1}{51}$$

The former gradient being the steeper, the general section is *concave* and points visible to one another.

There is just one more point to notice when ascertaining which is the highest intervening point in a case of an interrupted slope.

Presuming there is a knoll intervening, the top of which is represented by a complete contour, say, circular in shape, we notice that the line we have drawn joining the two points which we wish to know are visible or invisible one from the other, cuts the intervening knoll in two places, both the same height (as it cuts the same contour twice). The actual highest intervening point in this case is, where the top contour of this knoll cuts the line joining the two points *farthest away from the higher of the two points.*

PLATE XI.



CHAPTER XII.

COPYING, ENLARGING, AND REDUCING MAPS.

(*a*) *Copying.*—A sketch or map may be copied in several different ways, either by using tracing paper, by pricking through, by using thin prepared tracing cloth, or by using squares.

The three former methods require no explanation.

To copy a map by the use of squares, proceed thus :—

Rule squares of any convenient size over the original, then rule the same number of squares, and squares of the same size on a piece of paper. The whole of the detail is then put in by eye, square for square, drawing things which appear in the squares on the original, in corresponding squares on the copy.

(*b*) *Enlarging or Reducing.*—Sketches may also be enlarged or reduced by this method of squares.

A map or a piece of country on a map or a sketch, may be given to you to reduce or to enlarge. The following method will apply in either case.

If a whole map or sketch is given, the shape of it is almost certain to be either rectangular or square, but if a piece of country in between four or five points on the map is given, the shape when you have drawn lines joining the points and enclosing the country to be enlarged or reduced, may not be a rectangle or a square ; and *in this case you must enclose it in a rectangle*, the four sides of which pass through as many points of the figure as possible.

Supposing we have to enlarge a piece of country inside 5 points A, B, C, D and E, Fig. 1, Plate XI. Join the points with straight lines. Produce the longest side (A B) both

ways until you can set up lines at right angles to A B through E and C (see red lines). Through D draw a line parallel to A B meeting both these lines. We now have a rectangle X Y Q Z.

Now supposing the piece of country inside A, B, C, D, E was drawn on a map at 6 inches to the mile, and we wished to reduce it to 4 inches to the mile. We must now remember this rule, which applies either to reductions or enlargements. *As the scale of the original map is to the scale of the map we have to produce (i.e., the enlarged or reduced one) so is the long side* of the rectangle to x (the long side of the new reduced or enlarged rectangle).*

Now in the case of Fig. 1, Plate XI.

We first measure Z Q, the long side of the rectangle, and find it to be, let us say, 12 inches long (in actual size it is 2 inches). Therefore, according to the formula just quoted, we have to remember—

As 6 inches to the mile is to 4 inches to the mile, so is 12 inches to x inches ;

or as $6 : 4 :: 12 : x$

$\therefore 6x = 48$

$\therefore x = 8$ inches.

which is length of long side of new rectangle.

Now divide the rectangle enclosing the original map into squares by dividing Z Q into several conveniently sized equal parts, say into six parts.

On the lines Z X and Q Y measure off as many of the same sized equal distances as will go on to these lines, taking care the actual piece of country A B C D E is enclosed. Join up and form squares as per figure.

Divide the new line, which is 8 inches long, into the same number of equal parts, *i.e.*, six. Set up exactly the same number of squares on it, and then copy square for square, and you have a correctly reduced map of A B C D E.

---

*N.B.—If it was a whole map we had to copy, it would be "as the longer side of the map is to x," and if the map was square it would be "as one side of the map is to x."

Should the scale of the original map or sketch, and the scale at which it is to be reduced or enlarged be given in the form of Representative Fractions (R.F.) the procedure is exactly similar.

Example.

A map has a R.F. $= \frac{1}{10560}$. A copy is required on a scale of $\frac{1}{4800}$, measure the longer side of the map and say, for instance, it is 12 inches long.

Then as $\frac{1}{10560} : \frac{1}{4800} :: 12$ inches $: x$ inches.

$$\therefore \frac{x}{10560} = \frac{12}{4800}$$

$$\therefore \quad x = \frac{12 \times 10560}{4800} = 26\tfrac{2}{5} \text{ inches.}$$

The method of setting up the *same number* of squares on the original long side of map, covering whole map, and on the new line $26\frac{2}{5}$ inches, is then proceeded with, and square for square filled in with detail

CHAPTER XIII.

A NON-COMMISSIONED OFFICER ON PATROL.

RECONNAISSANCE.

Reconnaissance (topographical) is the process of obtaining and recording information concerning the nature and resources of the country, more especially its communications or the facilities for the movement of troops.

A reconnaissance consists of two parts—

(*a*) The sketch.

(*b*) The report.

We have dealt fully with the sketching portion, now for a few words with regard to the report.

It is very essential that N.-C. Officers, in sending back reports, should be clear and concise; the following is a guide on what to note and report:—

(1) ROAD.—To note everything in connection with it; *viz.*, (*a*) Roadway, level or hilly, condition good or bad, metalled or not, (*b*) bridges, (*c*) towns and villages, (*d*) water, (*e*) character of country, (*f*) rivers, (*g*) halting places, (*h*) camping grounds, (*i*) cross roads, (*k*) railways, (*l*) positions, (*m*) rate of marching.

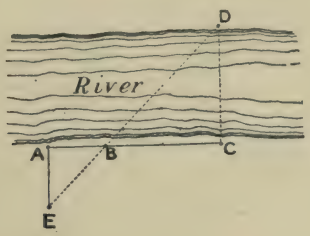
(2) RIVER.—(*a*) Direction of current, (*b*) *rate of current, (*c*) nature of banks, (*d*) nature of bed (if ascertainable), especially at fords, (*e*) character of country by side of river, if marshy, (*f*), whether liable to floods (this can be found from the inhabitants near the river), (*g*) whether

*NOTE.—In all these points the right bank is that which is on the right hand side when facing the same direction as the river is flowing. 1 mile an hour is "sluggish;" 2 miles an hour is "swift;" 3 miles an hour is "rapid;" 4 miles an hour is "very rapid."

navigable or not, and for what kind of boats, (*h*) if any boats are near and how the river is crossed, if not giving description of bridges, (*i*) depth of river, if possible, in case of having to use fords, (*k*) if any islands about, (*l*) breadth of river, (*m*) which bank commands the other, (*n*) whether tidal or not.

To ascertain the breadth of a river.

Select two points, one on either bank of the river, that are opposite to one another and close to the water's edge. These may be houses, trees, posts, fences, etc. Presume such points are at C and D in *sketch* below. Stand at C, pace C B any convenient distance at right angles to C D, mark B with a stake cut from a tree (6 ft. long); proceed in the same straight line to point A; the distance



B A must be half that paced from C to B; at A turn outwards back to the river and pace A E at right angles to A B, stopping at E, which is a point in line with your stake at B and the point D. Then A E is half the width of the river.

To ascertain the rate of the current.

Time a piece of wood or a cork floating between two points, the distance between which you have carefully measured beforehand. From this calculate the number of feet per minute which stream flows. This gives you the surface velocity.

The mean velocity is equal to $\frac{4}{5}$th of surface velocity.

To ascertain the supply or "yield" of a stream in gallons in a certain time.

Multiply the breadth of the stream by the average depth, then multiply this result by the mean velocity of the stream, ascertained by above method ; the result of this, multiplied by 9,000, will give you the number of gallons of water this stream will yield in 24 hours. The average depth is obtained by taking the depth of the centre, adding it to the depth at either bank, and dividing result by 2.

RAILWAYS.

The report on a railway may be grouped under the following heads :—

(1) *The country.*

(2) *The line—*

Permanent way.
Embankments, cuttings, tunnels.
Bridges.
Gradients.
Gauge, single or double.
Suitability for marching along.
Facilities for entraining and detraining.
Junction lines.

(3) *The stations—*

General construction.
Facilities for accommodation.
Facilities for defence.
Facilities for entraining and detraining, length of platforms
Water for men.
Water for engines
Fuel.
Approaches.
Camping grounds at hand.
Cross-over lines and sidings.
How lighted up at night.
Food storage capacities.

(4) *Rolling stock.*
(5) *Telegraph*, signal boxes, etc.
(6) *Officials.*

WOODS.

(1) Shape and extent.
(2) Whether undergrowth or not.
(3) Nature of trees, whether low or high branches, coniferous or deciduous.
(4) Whether thick or thinly placed.
(5) Communications through wood.
(6) Open spaces of considerable extent.
(7) Anything special to serve as a mark for the troops passing through.
(8) Whether exposed to artillery fire or not.

VILLAGES.

(1) Shape and extent (roughly).
(2) Nature of houses, *i.e.*, walls, windows, storeys.
(3) Nature of outside walls, etc.
(4) Surrounding country, wooded or not, or likely to give good cover to enemy, or commanding positions.
(5) Suitability for defence, remembering best for all purposes is a circular one. A salient village, *i.e.*, narrow front to the enemy, is easy to defend against flank attack, but poor front of fire.
(6) Means of communication between parts of the village, and means of retreat.
(7) Water and food supply.
(8) Number of troops which could be billeted, see Combined Training.
(9) Entrenching tools available.

BRIDGES.

(1) Width and length.
(2) Height from river.
(3) Material, iron, stone, wood, or brick, so as to show if able to bear guns and waggons.
(4) Shape, straight, girder, elliptical arch ; if latter, how many.
(5) If commanded from ground near at hand.
(6) Nature of piers and abutments.

ENEMY'S POSITION.

(1) Extent and natural strength.
(2) Any weak points you may notice.
(3) Approaches and cover.
(4) Best lines of attack.
(5) Entrenchments that you may observe.
(6) Advanced posts and outposts.
(7) Location of his guns.
(8) Any obstacles he may have put up, their nature and position.
(9) Numbers and vigilance.
(10) Report on the flanks and means of outflanking.
(11) Report very carefully on existence or not of any intermediate points, the capture of which may or may not be necessary or accessory to the plan of attack.

APPENDIX.

ANSWERS TO EXAMPLES OF SCALES SET ON PAGE 16.

(*a*) Construct a scale of yards at 4 inches to the mile.

From above we get the fact that 1,760 yards are represented by 4 inches. We can at once see that 2,500 yards will give us a line between 4 and 6 inches long.

To calculate exact length—

1,760 yards are represented by 4 inches.

$\therefore$ 1 yard is „ „ $\frac{4}{1760}$ „

$\therefore$ 2,500 yards are „ „ $\frac{4 \times 2,500}{1,760}$ inches.

This works down as follows :—

$$\frac{4 \times 2,500}{1,760}$$

$$= \frac{125}{22}$$

$$= 5{\cdot}6 \text{ ins.}—\textit{Ans.}$$

Draw a line 5·6 inches long, measured from the protractor; divide it into 5 equal parts, each part will represent 500 yards.

Subdivide the first division into 5 equal parts, each subdivision will equal 100 yards.

(*b*) Construct a scale of yards, R.F. $= \frac{1}{10000}$.

From above we have 10,000 inches on ground represented by 1 inch on the map.

$\therefore \frac{10,000}{36}$ yds. on ground are represented by 1 in. on map

(because 36 inches = 1 yard),

or roughly 277 yds. represented by 1 inch.

$\therefore$ 277 × 6 yds. (roughly) would be represented by 6 inches, or 1,662 yds. (roughly). In round numbers 1,600 yards.

To find actual length of scale—

We have $\frac{10,000}{36}$ yds. represented by 1 inch.

$\therefore$ 1 yd. is represented by $\frac{36}{10,000}$ ins.

$\therefore$ 1,600 yds. are represented by $\frac{36 \times 1.600}{10,000}$ ins.

This works out $\frac{36 \times 1600}{10,000}$

$= \frac{144}{25}$

$= 5{\cdot}7$ inches.—*Answer.*

Draw a line 5·7 inches long measured from the protractor, divide it into 8 equal parts; each division will represent 200 yards.

Subdivide the first division into 4 equal parts; each subdivision will represent 50 yards.

(*c*) Construct a scale, R.F. $= \frac{1}{15000}$, showing furlongs.

1 Furlong = 220 yards.

From above, 15,000 inches (ground) are represented by 1 inch (map).

$\therefore \frac{15,000}{36}$ yds. (ground) are represented by 1 in. (map).

$\therefore \frac{15,000}{36 \times 220}$ furlongs „ „ „ „

This works out to just under 2 furlongs to 1 inch.

Therefore if we take 10 furlongs we shall get a line about 5 inches long.

To calculate actual length of scale—

We have $\frac{15,000}{36 \times 220}$ furlongs represented by 1 inch.

$\therefore$ 1 furlong is „ $\frac{36 \times 220}{15,000}$ ins.

$\therefore$ 10 furlongs are „ $\frac{36 \times 220 \times 10}{15,000}$ ins.

This works out $\frac{\cancel{12}\ \ 11}{\cancel{36} \times \cancel{220} \times \cancel{10}}$

$\cancel{15,000}$

$\cancel{50}$

25

$= \frac{132}{25}$

$= 5{\cdot}2$ inches.—*Answer.*

Draw a line 5·2 inches long, divide it into 10 parts, each division equals 1 furlong.

(*d*) The distance between two places on a map is measured and found to be 3·6 inches; when paced on the ground it is found to be 890 yards. Draw a scale of yards for this map.

We have from above that 890 yards (ground) are represented by 3·6 inches (map). We can see at once that something less than double this number of yards will give a scale about 6 inches long.

Let us select 1,400 yards.

To calculate actual length of scale—

We know 890 yards are represented by 3·6 inches.

$\therefore$ 1 yard is „ „ $\frac{3{\cdot}6}{890}$

$\therefore$ 1,400 yards are „ „ $\frac{3{\cdot}6 \times 1{,}400}{890}$

This works out as follows when the *decimal point is taken out :—

$$\frac{36 \times 1400}{890 \times 10}$$

$$= \frac{504}{89}$$

$= 5{\cdot}6$ inches.—*Answer.*

---

*To get rid of a decimal point turn the number into a fraction thus—

$2{\cdot}3 = \frac{23}{10}$ and

$2{\cdot}32 = \frac{232}{100}$ etc.

Draw a line 5·6 inches long, divide into 7 equal parts, each division will represent 200 yards. Subdivide first division into 5 equal parts; each subdivision will equal 40 yards.

(*e*) You are detailed to make a road reconnaissance at a scale of 1 inch to 1 mile. You have a bicycle which you intend to use while sketching; it travels 5 yards for one revolution of the pedal.

Construct a suitable scale of revolutions.

Here our unit in the scale will be revolutions.

Each revolution = 5 yards.

The proportion at which the scale is to be drawn is 1 inch to 1 mile.

The question we must ask ourselves is then, how many revolutions (or in other words "sets of 5 yards") shall we require at a proportion of 1 inch to 1 mile to give us a line about 6 inches long.

From above, 1,760 yards are represented by 1 inch,

or $\frac{1760}{5}$ revolutions „ „ „

in other words 352 „ „ „ „

$\therefore$ 352 × 6 „ „ „ 6 inches.

Therefore if we select about 2,000 revolutions, as a round number, it will give us a line about the required length.

To calculate exact length of this line we have from above;

352 revolutions are represented by 1 inch.

$\therefore$ 1 revolution is „ „ $\frac{1}{352}$ inch.

$\therefore$ 2,000 revolutions are „ „ $\frac{2{,}000 \times 1}{352}$ „

$= \frac{2000}{352}$

$= 5{\cdot}6$ inches.

Draw a line 5·6 inches long, divide it up into 10 parts, each part represents 200 revolutions.

Subdivide 1st part into 4 parts, each subdivision represents 50 revolutions.

(*f*) You are about to make a sketch on horseback on a scale of 2 miles to 1 inch, and you know that your horse trots at the rate of 7 miles per hour. Draw a *scale of time* suitable to work with, and give the representative fraction.

$$\text{R.F.} = \frac{1}{2 \times 1760 \times 36} = \frac{1}{126720}. \quad \textit{Answer.}$$

Your horse trots 7 miles per hour.

$$\text{In other words } \frac{7 \times 1760}{60} \text{ yards per minute,}$$

$$= \frac{616}{3} \quad \text{,,} \quad \text{,,} \quad \text{,,}$$

To return to the scale we are using, which is 2 miles to 1 inch, we have

2×1760 yards are represented by 1 inch,

$\therefore$ 1 yard is represented by $\frac{1}{2 \times 1760}$ inches,

$\therefore \frac{616}{3}$ yds. (or 1 minute) is represented by

$$\frac{1}{2 \times 1760} \times \frac{616}{3} \text{ inches,}$$

or 1 minute is represented by $\frac{7}{120}$ inches.

We require a scale between 4″ and 6″ long,

$\therefore$ 90 minutes (or $1\frac{1}{2}$ hours) are represented by

$\frac{90 \times 7}{120}$ inches $= \frac{21}{4}$ inches $= 5{\cdot}25$ inches length of scale.

Draw a line 5·25″ long. Now this might be divided up two ways.

1. Divide the line into 9 equal parts, each of 10 minutes; subdivide the first part into 9 parts each representing 1 minute.
2. Divide the line into 6 equal parts, each representing a quarter of an hour (15 minutes); subdivide the first part into 3 equal parts, each representing 5 minutes.

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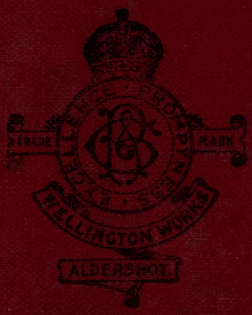
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